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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See Advertisement page 50.

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4078

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See their Illus. Advertisement, page 123, last week.

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See page 107. 6455

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See Advertisement page 54. 6462

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Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
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All Gauges and Types.
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BUILDERS of RAILWAY CARRIAGES & WAGONS.
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Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
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Yarrow Patent
Water-tube Boilers.
6877
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YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
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See Full Page Advt., page 70, Oct. 18.

Forgings.
Walter Somers & Co., Ltd.,
HALESOWEN. 6449

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 43, Oct. 25. 3402

Taylor & Challen
Presses.
8198
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement Oct. 18.

Railway
Switches and
Crossings.
T. SUMMERSON & SONS, LIMITED,
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Gas and Oil Engine Repairs.
—H. J. DAVIS & CO., Great Eastern Road, Stratford, E. 15.
Tel.: 736 and 737 Stratford.
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Cement.—Maxted & Knott,
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WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles as present made abroad, and will be pleased to hear from firms desiring such work executed. 9311

STEEL JOISTS,
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BRIDGE RAILS, &c.
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Pott, Cassels & Williamson,
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7008
See half-page Advertisement page 55, Nov. 1.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 6841

Optical Society.—Meeting,

Thursday, 14th November,
At Imperial College of Science and Technology,
South Kensington. Seven p.m.
The following communications will be submitted—
(A) Some generalised forms of an Optical Equation, by T. Smith, B.A.
(B) Notes on the designs and manufactures of Binoculars, by H. S. Ryland.
Samples of binoculars and die castings from various British manufacturers will be exhibited.
Forms of proposal for membership should be received by 13th November. O 458

Engineering Special Classes.

Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 284, Oxford Rd., Manchester.

TENDERS.

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IN PRIZE.
By ORDER and for ACCOUNT of the MARSHAL of the ADMIRALTY.

To be Sold by Public TENDER:—

About 500 boxes TINPLATES lying at Hull ex "ESROM."
To be sold subject to Government restrictions as to export and to the regulations of the Ministry of Munitions.
Tenders, in envelopes marked "Tender for Tinplates," and addressed to THE ADMIRALTY MARSHAL, Royal Courts of Justice, Strand, London, W.C. 2, must be received not later than NOON on WEDNESDAY, 27th NOVEMBER, 1918.
All further particulars may be obtained from the Selling Brokers, MORRISON, KEKEWICH & CO., 270, Gresham House, Old Broad Street, London, E.C. 2. O 446

TO BE SOLD BY TENDER.—A Prosperous ENGINEERING CONCERN in the West of England.

Messrs. FULLER, HORSEY, SONS, & CASSELL are instructed by the Proprietors, who are retiring from business, to invite

Tenders for the Purchase, in one lot, as a going concern, of the BUSINESS and ASSETS

(except book debts) of an old established ENGINEERING WORKS and FOUNDRY in an important town in the West of England. The property is freehold, with substantial buildings thereon, equipped with MODERN PLANT and MACHINERY, and the Stock, Stores, and Work in progress; as also the GOODWILL OF THE BUSINESS, together with the valuable collection of patterns and drawings will be included in the purchase.
Tenders must be in the form contained in the particulars of sale, and should be delivered under seal at the offices of Messrs. Fuller, Horsey, and Co., not later than Four p.m. on TUESDAY, December 10th, 1918.
Particulars, with plans and conditions of sale, are in course of preparation, and when ready may be obtained (price 5s. per copy) of FULLER, HORSEY, SONS, & CASSELL, 11, Billiter Square, London, E.C. O 432

CITY OF NOTTINGHAM.

THE WORKS AND WAYS COMMITTEE are prepared to receive

Tenders for the Supply of the

under-mentioned STORES and MATERIALS, the contracts to commence on the 1st January next, and to terminate on the 31st December, 1919:—
(A) Cement.
(B) Blue Lias Lime.
(C) Red Bricks.
(D) Blue Bricks.
(E) Timber.
(F) Stoneware Pipes, &c.
(G) Stoneware Pipes, &c. (Patent Joints).
(H) Iron Castings, Iron Gulleys, &c.
(I) Yorkshire Flags, Kerb, &c.
(J) Granite Sets, Kerb, and Broken Granite.
(K) Ironstone Slag, Chippings, &c.
(L) River Gravel.
(M) Coal.
(N) Picks, Shovels, Scoops, &c.
(O) Ironmongery.
(P) Scavenging and other Brushes.
(Q) Disinfectants.
(R) Refined Tar.
(S) Pitch.
(T) Creosote Oil.

Forms of Tender may be obtained on applying to Mr. Arthur Brown, M.Inst.C.E., City Engineer, Guildhall, Nottingham, on payment of a deposit of 5s. each, which will be returned on receipt of a bona-fide tender, in accordance with the specifications, providing such tender is not withdrawn, and is delivered by the time stated below.
Patterns and samples may be inspected at the Eastcroft Depôt, London Road, Nottingham.
The committee will not consider any tender except on the authorised form of Tender, which must be delivered to the undersigned, in the official envelope provided, on or before Thursday, 28th November, 1918.
The lowest or any Tender will not necessarily be accepted, and Tenders will only be accepted from persons who conform to the conditions as regards paying the local standard rate of wages, &c., and to the working rules of the Nottingham District applicable to the various trades.
By Order,
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham.
2nd November, 1918. O 390

AGRICULTURE AND DAIRY MACHINERY.

Tenders are Invited for

the MANUFACTURE of 10-gallon Railway Milk CHURNS of a standard pattern. Written applications for tender forms, drawings and specifications may be made not later than November 14th, 1918, to the CONTRACTS DEPARTMENT, C.H. 5, Ministry of Munitions, 1, Grosvenor Place, S.W. 1, where a sample Churn will be on view. Applicants should state approximately their estimated weekly output. O 371

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1919.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of January next, and terminate on the 31st of December, 1919.

	No. of Form.		No. of Form.
Asbestos and Packing	1	Oils	26
Barrows and Trucks...	2	Paints, Colours and Wallpaper	27
Baskets and Mats ...	3	Ropes and Canvas ...	28
Brushes, Brooms, &c.	4	Rail Fastenings, Iron	29
Brass Fittings for Gas and Water	5	Rail Fastenings, Steel	30
Bolts, Nuts and Rivets	6	Screws, Split Pins, Nails, &c.	31
Bricks, Slates, Earthenware Pipe, &c. ...	7	Sheet Tin, Lead, Gun Barrel, &c.	32
Chain	8	Steel Tyres, Axles and Plates	33
Cement...	9	Steel and Copper Tubes, Copper Plates and Ingots	34
Candles and Soap ...	10	Steel Castings ...	35
Carriage Fittings ...	11	Staffordshire Iron, Wire, &c.	36
Carriage Trimmings...	12	Springs, Steel, and Files...	37
Creosote Oil	13	Soft Goods	38
Drysalteries	14	Timber, &c.	39
Fog Signals	15	Tools	40
Farm Produce Boxes	15A	Tool & Barrow Shafts	41
Glass	16	Varnishes	42
Grease...	17	Wagon Covers and Tarpaulins	43
Gas Mantles, &c. ...	18	Waste and Wicking	44
Iron & Steel Forgings	19	Yorkshire Iron ...	45
Iron Castings ...	20		
India Rubber Goods	21		
Lime	22		
Leather and Belting	23		
Lamps and Tinware	24		
Locks, Rainwater Goods & Hardware	25		

Forms of Tender can be obtained, on payment of 6d. each, from the STOREKEEPER, GENERAL STORES DEPARTMENT, BROADSTONE STATION, DUBLIN. *Please do not send Stamps.*
Patterns and Samples can be inspected at the same place on and after 1st prox., between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon).
Contractors cannot be allowed to Tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.
The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.
The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No. ———," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before Ten a.m. on the 19th November.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order,
PERCY A. HAY,
Broadstone Station, Dublin, Secretary.
October, 1918. O 439

APPOINTMENTS OPEN.

Manager Required for Small

Steel Foundry in Hong Kong, which is being enlarged and reorganised. Applicants must be able to advise and superintend the laying out of modern steel foundries, including crucible, electric and open hearth furnaces. Applications from suitable discharged men would be considered.—Apply, stating age, experience, qualifications, salary required, references, &c., to BOX 759, care of Leathwait & Simmons, 6, Birchin Lane, E.C. 3. M 718

Wanted, Works Manager,

with special knowledge of Accumulator manufacture, preferably with experience of Traction batteries. Must be practical, energetic and good organiser. Applications must contain full particulars of experience and salary required. Only first-class men need apply.—Address, O 284, Offices of Engineering.

Wanted Purchasing Clerk

should have experience in purchasing Electrical Stores and Fittings, Works Stores, etc. Applications must contain full particulars of experience and salary required.—Address, O 285, Offices of Engineering.

Wanted a Cost Clerk, Pre-

ferably with experience in Cable and Electrical manufacture. Must be capable of instituting and organizing detailed Costing Department. Applications must contain full particulars of experience and salary required.—Address, O 286, Offices of Engineering.

Wanted, Immediately, by

large firm (2000 hands) in North Midlands, experienced, capable MAN as Assistant Works Manager, to take control of cycle production on large scale. Highest post-war prospects. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and O 193.

Required Capable Man as As-

SISTANT for the Electrical and Engineering Section of the Buying Department of an important Company. Commencing salary £260. Reply, giving full particulars of experience and copy testimonials from past employers, to Z. S. 678, care of Deacons, Leadenhall Street, E.C. 3. O 283

Required, Chief Assistant, to

Buying Department of engineering firm. Former experience essential, technical knowledge preferred. No one resident more than 10 miles away or employed on Government work need apply.—Address, O 429, Offices of Engineering.

Salesman Wanted for South

of England, one with technical knowledge of iron and steel trade preferred.—Must be first-class man.—Address, O 340, Offices of Engineering.

Salesman Wanted for Mid-

lands. Some engineering knowledge. Salary, expenses and commission. State experience and salary expected.—Address, O 430, Offices of Engineering. O 430

SOUTH METROPOLITAN GAS COMPANY.

The South Metropolitan Gas

Company in order to complete the replacement of losses due to the war in its Engineering, Chemical and Commercial staff, is PREPARED to CONSIDER APPLICATIONS from PERSONS who are, or who have been, in His Majesty's Forces.
Every application must state the nature of the services given to the nation and be addressed to the SECRETARY, 709, Old Kent Road, S.E. 15.
5th November, 1918. O 420

Required for an Important

provincial Gas Company, an experienced and fully qualified CONSTRUCTIONAL ENGINEER, with special knowledge of modern Gas Works Design, and Coal Handling Plant. Salary appropriate to qualifications.—Write, giving full particulars to O 386, Offices of Engineering.

Wanted at Once, Mechanical

ENGINEER, with knowledge of electrical work (D.C. motors and lighting), motor vehicles, steam and petrol. — Address, WINCHESTER BREWERY CO., Ltd., Winchester. O 389

Wanted, Engineer, to act as

Chief Assistant in Aero Engine Testing Shop in Midlands. Must have Petrol Engine experience and hold Engineering Degree or equivalent qualification. No person already employed on Government work will be engaged.—Apply, in first instance, stating salary required, &c., to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 6136. O 391

Wanted, a Gentleman of

Engineering and Commercial experience, if possible with experience in the Motor Industry, to fill an important post in Australia in connection with propaganda on behalf of British Manufacturing interests. Applicants with a thorough knowledge of Australasian conditions will be given preference. The highest references will be required.—Address, O 378, Offices of Engineering.

Assistant Chemist Required,

for Engineering works near London. Must be well up in Iron, Steel and Non-ferrous Analysis. No one resident more than 10 miles away or employed on Government work will be engaged.—Address, stating experience, age and salary required, to O 366, Offices of Engineering.

Engineer Wanted for Chemical

Works, Box No. M 923.—This POST is now FILLED, and we herewith thank all those who have kindly sent applications for the same. O 463

Wanted Assistant Chemist

with experience in the analysis of iron, steel, and non-ferrous alloys, for large works in the North of England. No one at present engaged on Government work need apply. Write stating age, experience and wage required to nearest EMPLOYMENT EXCHANGE, quoting No. A 6192. O 166

A Large Firm, Engaged in

the tube industry in the Midlands, has a VACANCY for an ASSISTANT MANAGER. The position offers an excellent opening for a young energetic man not afraid of work.—Apply, in first instance, stating age, experience, place of education, and full particulars, O 241, Offices of Engineering.

Firm in Yorkshire District

REQUIRES services of ENGINEER under 30 years of age, preferably one holding first-class B. of T. Certificate and capable of inspecting and reporting on steam plants. No one already engaged on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, stating experience and salary required, mentioning this Journal and O 316.

Engineer of Methods, for

Planning Department, REQUIRED immediately by controlled establishment, in London area, 2000 employees, for small and accurate repetition parts of electrical instruments. Electrical knowledge essential. Applicants must be first-class mechanics and be able to organise a growing department. Preference given to one with knowledge of piece rates. Only applicants having held a similar position need apply. No person already engaged on Government work need apply.—Apply, stating fully, experience, age, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 6295. O 270

Required, for Small Works in

Gloucestershire, practical ENGINEER, capable of carrying out improvements to Plant. Must be man of resource with business abilities.—Address, stating experience and salary required, O 370, Offices of Engineering.

Required for Service on

the Gold Coast Government Railway:—
EUROPEAN DRAUGHTSMAN AND CHIEF CLERK
Qualifications: Must have served as Assistant Engineer and possess Railway experience.
DRAUGHTSMAN AND TECHNICAL INSTRUCTOR,
Qualifications: Must be capable Mechanical Draughtsman with sound Technical Knowledge of Locomotives and Machinery, and possess ability to instruct and deliver lectures to apprentices, &c.
Engagement in each case will be for two tours, each of twelve months' service. Salary £360—£10—£400, with a war bonus of £60 per annum whilst supporting dependents in England. Free quarters and first-class passages. Liberal leave in England on full salary.
Candidates should apply at once by letter giving full particulars to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1.
No person engaged on Government work or eligible for the Army need apply. O 459

West Africa.—Wanted Com-

petent ENGINEER with First Class Board of Trade Certificate and supervision experience, to take charge of fleet of River-craft and small repair shop. Liberal salary to capable and steady man.—Write stating experience, age, etc., to CONSULTANT, care of Chas. Graham & Co., 14, Water Street, Liverpool. O 338

Wanted, An Engineer

to proceed to INDIA, and there assist establishing Small Machine Tools of British make. Sound engineering training combined with commercial knowledge and selling ability essential. Preference to discharged Officer and unmarried man.—Address, Box 4, c/o. Dawson's, 121, Cannon Street, London, E.C. 4. O 416

Teacher with Engineering

Qualifications is REQUIRED for the Austin Technical School. Applications stating qualifications, experience and salary required should be submitted at once to the TECHNICAL DIRECTOR, Longbridge, near Birmingham. O 406

Naval Architect Wanted for

design of Reinforced Concrete Cargo Boats. No concrete specialist knowledge required. Opening for capable man well up in fittings, machinery and lay out. No person at present engaged on Government work need apply.—Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, quoting O 374 and this Journal.

Marine Engineer Required

for British North Borneo. Salary £490 to £595 with travelling allowance. Pensionable, but one year's probation. Passage paid.—Applications to Messrs. GREGORY, RYLES & WARING, 12, Dean's Yard, Westminster, S.W. 1. O 444

Chief Draughtsman.—Wanted,

by a well-known firm of Engineers and Shipbuilders, a First class MAN to take charge of Shipyard Drawing Office. Must be conversant with Admiralty practice and capable of designing and preparing plans and calculations for moderate size merchant work steam yachts, and passenger vessels. No one already employed on Government work will be engaged. — Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and O 411.

Draughtsman.—Experienced

Constructional Engineering DRAUGHTSMA REQUIRED.—Apply by letter, stating age, full particulars of experience, salary required, and liability for military service, to CHIEF ENGINEER, 109, Leadenhall Street, E.C. 3.—No person already employed on Government work or residing at a distance of more than 10 miles away need apply. O 412

Draughtsmen Wanted, by

firm of Electrical Engineers in Midlands, with good mathematical and mechanical training, capable of mechanical design and calculation of stresses on high and low speed electrical machinery. No person already on Government work will be engaged. — Apply, your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required and quoting No. A 6352. O 368

Wanted in Government

Office, South Eastern Counties, a good Civil Engineering Draughtsman, experienced in surveying, steel and general building construction. Apply by letter, stating age, salary required, full particulars of experience and enclosing copy of recent testimonials to BOX 821, Willings, 125, Strand, London, W.C. 2. O 462

Draughtsmen Required, for

Seaplane Drawing Office. Permanencies to suitable applicants. No person already on Government work will be engaged.—Apply, stating full particulars of experience, references, &c., to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 6368. O 467

Draughtsman Wanted for

tools and jigs for engineering works in East Midlands. No one on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 6234. O 197

Draughtsman, with Good

aeronautical experience, REQUIRED for aeroplane factory, London district. No person resident more than 10 miles away or already on Government work need apply.—Address, stating age, full particulars of qualifications and salary required, O 206, Offices of Engineering.

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Wanted at Once, a Thor-

oughly capable DRAUGHTSMAN with large and varied experience in Electric Crane design to undertake standardisation work. Good salary and prospects for the right man. State age, experience and salary required. No one already on Government work will be engaged. — Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and O 149.

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Railway Company in London, with knowledge of electric signal interlocking preferred. State age and experience.—Address, O 336, Offices of Engineering.

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REQUIRED, accustomed to Diesel or Semi-Diesel Engines, for large Engineering Works, Manchester district. No one on Government work will be engaged.—Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 6160. O 40

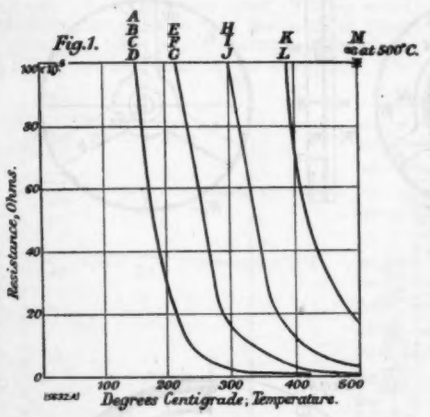
Rate-Fixer wanted, thorough-

ly experienced, capable of starting up department in large factory (Birmingham district) making numerous products on manufacturing lines. Permanent and progressive position to suitable man.—Apply stating age, experience, salary desired to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 6206. O 325

NOTE ON THE EFFECT OF TEMPERATURE ON THE RESISTANCES OF SPARK PLUG INSULATIONS.

J. D. Morgan, A.M.I.C.E., M.I.E.E.

In the following is described an investigation of the effect of temperature on the resistances of insulations used in spark plugs for internal-combustion engines. The particular question on which information was desired was whether the conductances of plug insulations at temperatures likely to be found in engine cylinders are sufficient to short circuit the high-tension system of a magneto or induction coil and thereby extinguish sparking at the plugs. There seems to be no widespread agreement among engineers as to the temperatures to which plug insulations are raised in service. The temperature differs considerably in different engines. Some are of opinion that plug insulations need not be designed to resist a higher temperature than 300 deg. C., whilst others are of opinion that temperatures as high as 600 deg. C. may be expected. Satisfactory operation of a spark generator, whether it be a magneto or induction coil, depends on, among other factors, adequate plug insulation. It is important to know, therefore, exactly how commercial insulating materials behave under temperature conditions likely to be found in an engine. The results of temperature tests on plug insulations have already been published by different investigators, but so far as the writer is aware they have not been associated with figures which show the limits at which fall of insulation resistance renders a plug useless. As is well known, certain types of insulating material show a rapid drop in resistance above a certain temperature. It is also well known that both magnetos and induction coils are capable in different degrees of overcoming the adverse effect of some leakage at the plug without serious deterioration of the sparking. With the object of bringing these two facts into quantitative relationship, the investigation was divided into two parts, the one dealing with the effect of heat on plug insulation and the other with the effect of plug leakage on sparking.

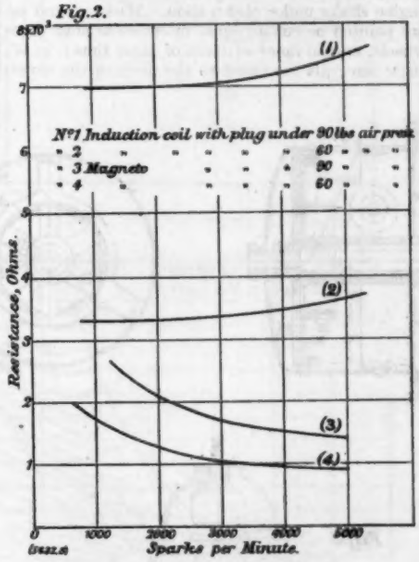


Thirteen plugs by different makers were chosen. These are designated by letters, and the country of origin together with the nature of the insulation are given in the following table:—

Plug.	County of Origin.	Insulation.
A	U.S.A.	Céramic.*
B	"	"
C	France	"
D	Great Britain	"
E	"	"
F	"	"
G	Germany	"
H	France	"
I	"	"
J	Great Britain	"
K	"	Mica.
L	"	"
M	U.S.A.	"

* Trade term "porcelain."

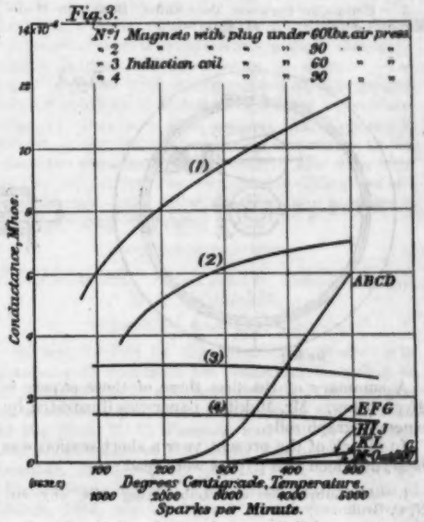
Each plug was tested as a whole, that is to say with the insulation contained in its metal body as in service, and each plug in turn was heated in a small electric muffle. A megger was connected by wires with the central electrode and the body, and the temperature of the muffle interior was indicated by a thermo-couple instrument. Before each test the plug was heated for 1 hour at 500 deg. C., and the resistances were taken at intervals during the subsequent cooling. The results are shown in Fig. 1, where resistance in megohms is plotted against temperature. To avoid the confusion of lines which would be inevitable in a small-scale diagram the results have been grouped. A and B were practically identical, as also were C and D. The temperature difference between the two pairs at 100 megohms resistance was 20 deg. C. The differences between E, F and G were sufficiently small to justify their collective representation by a single line. When indicating 100 megohms resistance F was at 10 deg. C. higher temperature than E, and G 20 deg. C. higher than F. A mean line has been shown in the diagram. H, I and J were practically identical, also K and L. Only one plug (M) gave an infinity resistance reading at 500 deg. C., and the insulation in that case consisted solely of a mica wrapping. In the other two mica plugs, K and L, mica washers were used.



From the rapid manner in which the resistances fall off above certain temperatures it might be inferred that the insulations were practically useless above those temperatures, but it must be remembered that the resistances are recorded in megohms, and a resistance as high as 1 megohm would appear very small on the diagram. Perfect plug insulation, though always highly desirable, is not absolutely essential to proper operation of a spark generator, and before any judgment can be pronounced on the serviceability of the plugs tested it is therefore necessary to know what leakage at a plug will completely prevent sparking by a magneto or induction coil.

For the purpose of obtaining this information a plug was secured to a compressed air chamber (of the kind frequently used for testing plugs and spark generators), and in parallel with the plug was arranged a variable water resistance. This system was connected in turn to a magneto and an induction coil, and the resistances just capable of putting out the sparks at different speeds measured by a megger. The magneto (of British manufacture) was of the rotary wound-armature type giving two sparks per revolution, and the coil (made in the United States of America) was of the usual cam-operated interrupter type working with a 6-volt battery. This particular coil was designed for six-cylinder engines, and was constructed to give sparks of approximately uniform energy over a normal working range of speed. Each apparatus was tested with the plug gap under air pressure of 60 lb. and 90 lb. per square inch, the sparking voltages being respectively 6,400 and 8,800. As would be inferred from the general characteristics of these two types of spark generators the magneto was capable of overcoming a larger plug leakage than the induction coil. The results of the test are shown in Fig. 2. In this diagram the leakage resistance just sufficient to extinguish sparking is plotted against sparks per minute, the latter being adopted instead of revolutions per minute to make the tests on the two machines comparable.

It is not easy to get at a glance the full significance of the diagrams shown in Figs. 1 and 2 when combined in a single diagram. The results have therefore been differently expressed in another diagram shown in Fig. 3. Here the results are brought together, and instead of showing leakages in terms of resistance they are shown by the reciprocal of resistance, namely, conductance. As will be seen, the conductances of all the plugs (excepting M) rise in differing degrees after certain temperatures have been passed. The conductance or leakage necessary to extinguish the magneto sparks rises with the speed of the machine, whilst with the induction coil it falls slightly. In both cases increase of spark voltage as determined by the air pressure in the test chamber diminishes the permissible leakage. The induction-coil tested is clearly not so well adapted to deal with plug leakages as the magneto. As regards the plugs, it is obvious that the permissible leakage must never be sufficient to extinguish the sparks. From the tests it is shown that in the case of plugs A to D, working with the induction coil when giving 3,000 sparks per minute under the conditions of the test indicated by line 4, sparking would disappear at a temperature of 340 deg. C., whilst with the magneto under conditions corresponding to line 2 sparking would disappear at 500 deg. C. Similarly, in the case of plugs E to G, sparking by the coil under line 4 conditions would disappear at 480 deg. C. and not at all with the magneto. In the case of plugs H to M, temperatures up to 500 deg. C. would have no effect on the sparking produced either by the coil or the magneto.



In interpreting the results of these tests it is necessary to bear in mind that the spark voltages, whilst of the order used in the testing of spark generators, are undoubtedly higher than are met with in engine practice. There the spark voltage is usually of the order of from 5,000 to 6,000. The difference between these figures and those of the tests may be accounted for by the higher temperature of the engine gases. In the tests the temperature in the compressed air chamber was that of the atmosphere.

The net result of the investigation on the practical side is, in the writer's opinion, that insulation leakage due solely to temperature as found in the plugs tested is not so serious as curves such as those

shown in Fig. 1 might indicate. It is, however, always desirable to keep plug leakage at high temperatures as low as possible, and leakages as high as those found in plugs A to D should be avoided.

The writer's acknowledgments are due to Mr. Ahmed M. Mehrez, B.Sc., for his assistance in carrying out the experiments on which this article is based.

JAPANESE SOCIETY OF NAVAL ARCHITECTS.

This society has been very active during the past year, as in previous years. In 1917, its principal meeting took place in November; thereat five papers were read and discussed, viz. :—

1. "Devices for Comparing the Rotation of Shafts," by Professor Tuyehiro, D.Eng., and Mr. T. Tsuchiya.
2. "Measuring CO_2 in Chimney Gas and a New CO_2 Recorder," by Mr. A. Naito, Consulting Chemist.
3. "Weight Constituents of a Cargo Ship," by Mr. H. Hashiguchi, Superintendent Engineer, Nippon Yusen, Kwaisha.
4. "The Stokes Wave and Trichoidal Deep-Sea Waves," by Professor S. Yokota, D.Eng.
5. "Repulsion between Two Ships, Based on Model Experiments," by Mr. H. Makita.

A summary of the first three of these papers is given below. Mr. Makita's paper was illustrated by cinematograph rolls.

In March of the present year a short session was held, at which two papers were read :—

1. "Air Lubrication and Lubricating Oils," by Mr. N. C. Bruhn.
2. "Cause of Failure of the Quebec Bridge," by Professor Hiroi, D.Eng., C.E.

In April another session took place, and three papers were read :—

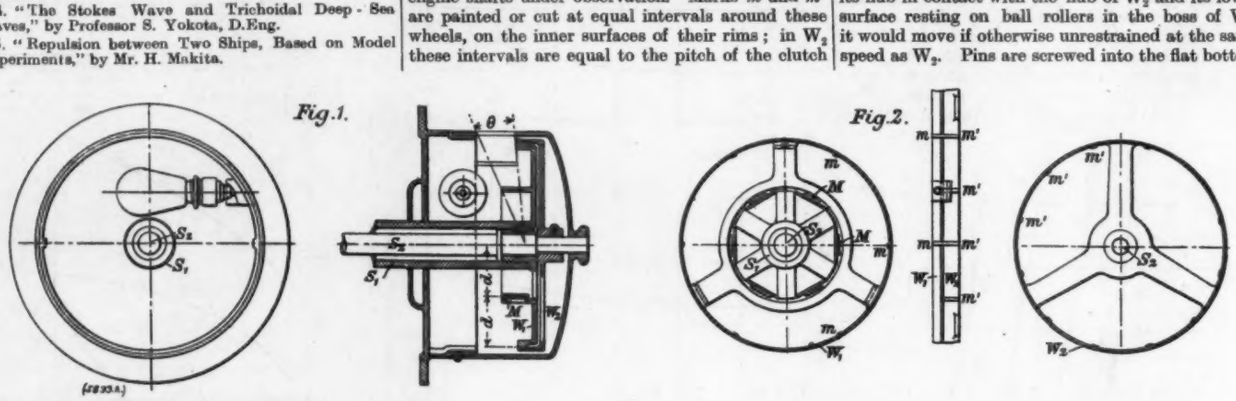
1. "Female Workers (in England) in Shipbuilding and Marine Engineering," by Mr. S. Oshi, Chief Surveyor of the Mercantile Marine Bureau Proving House.
2. "Diesel Engines for Main Propelling Machinery of Cargo Ships," by Professor Baron Shiba, D.Eng.

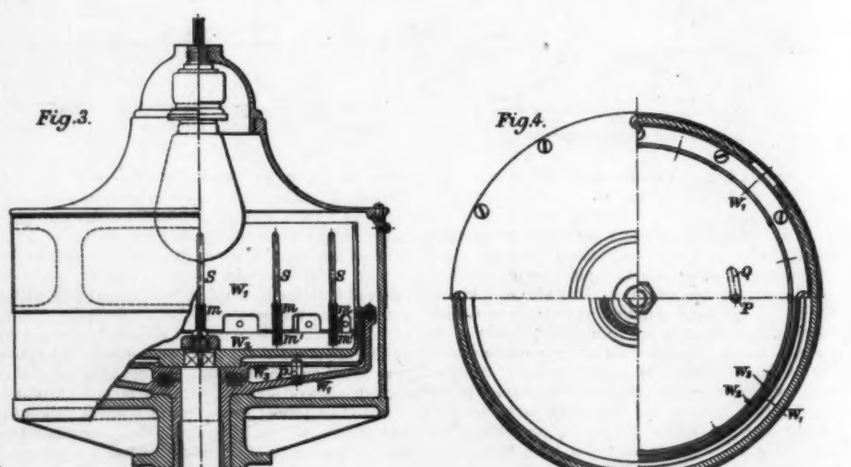
These papers treated the subjects dealt with in a somewhat popular style. Still more popular were the excursions made in connection with the meeting. The Navy Department experimental tank, for ascertaining resistance of models, &c., was visited by special permission. The work done at the tank in connection with resistance screw propulsion, rolling of ships, hydroplanes, submarines, &c., was carefully explained to the visitors. The naval arsenal close beside the experimental tank, was also visited. The Tokyo Ishikawajimia Shipbuilding Company's works formed a very attractive centre. These works have been greatly developed recently, both generally and in shipbuilding plant particularly; steel ships, four in number, some as large as 3,000 tons deadweight, are under construction. Engines and boilers for ships built elsewhere, for instance, all those of the Asamo Shipbuilding Company, are manufactured here. The building of travelling cranes and shipyard tower cranes has long been, and still remains, a large part of the staple industry of the firm. The Tokyo branch of the Niigata Ironworks, which were visited, have in hand many varieties and sizes of motor engines for fishing and other vessels; the largest, running up to 320 h.p. Machine tools are also a feature of the works. Various other shipyards (some very small) within the Tokyo area, were also visited. These small shipyards are entirely occupied with the construction of wooden vessels.

Devices for Comparing the Rotation of Shafts.

Messrs. Suyehiro and Tsuchiya, in their paper, begin with a general explanation of the purpose of a synchroscope as an apparatus to detect the comparative speed of two shafts, and if possible their relative phase; they mention what has been done by others in the same field and then describe two forms of instrument for which they are responsible. In the first the underlying principle is the same as in Professor Suyehiro's torsion-meter, described at the Institution of Naval Architects, London, in 1914*; the principle is that an object rotating with a shaft can be made visible by placing a mirror parallel to the axis of revolution at half the distance of the object from the axis; in this case the image of the object in the mirror appears stationary at the axis. In Figs. 1 and 2, wheels W_1 and W_2 are shown at the end of two shafts s_1 and s_2, outer and inner, connected directly or indirectly with the engine shafts under observation. Marks m and m^1 are painted or cut at equal intervals around these wheels, on the inner surfaces of their rims; in W_2 these intervals are equal to the pitch of the clutch which is to engage either one or other engine to the main shaft; in W_1 the intervals are double. The purpose of the apparatus then is to make the marks visible, and this is done by the mirrors M on the wheel W_1. Opposite each mark m parallel to the axis and bisecting the distance from axis to m; as the marks m appear successively, each in its mirror, and always at the axis of the shaft, they give the impression of a fixed mark there. The marks m^1 on the wheel W_2 are also visible in the mirrors M, but unless the shafts are in synchronism they are not fixed but move one way or the other according to the difference in the peripherical speeds of the wheels, the motion having the appearance of occurring on a cylindrical surface passing through the centre of the shaft. One objection to the instrument just described is the use of glass, the breaking of which would render the instrument useless. A modification of the idea produced the second form of instrument described. Slits equal in number and interval to the indicating marks m are cut in the cylindrical rim of the pan-shaped wheel W_1 (see Figs. 3 and 4); looking through these slits the marks appear as stationary, in virtue of the old-fashioned zoetrope principle. Similar marks m_1 on W_2 viewed through the same slits are seen intermittently, crossing the marks m in direction determined by the relation of speed of the two shafts.

Thus far the apparatus is complete, as long as the speed difference is not too much to cause visual confusion; to deal with wider differences, a third wheel W_3 is added; it works loose on the two shafts, its hub in contact with the hub of W_2 and its lower surface resting on ball rollers in the boss of W_1; it would move if otherwise unrestrained at the same speed as W_2. Pins are screwed into the flat bottom of W_1 and short circular slots Q cut in W_3; these slots are in length just sufficient to allow of the relative position of W_2 and W_3 changing to the extent of one-half the interval of the marks m; thus if the speed of W_2 is greater than that of W_1 it carries W_3 until the pins stop in in the one direction if less it holds W_3 until the pins stop it in the other direction; to indicate the change, openings O are cut in W_1 as shown in the figure, and the inside surface of W_3 is painted in two different colours, every alternate section—corresponding to one-half of the interval of the marks m—having the same colour. Thus when W_1 overruns W_2 the one colour is seen through the slots of W_1; otherwise, the





Figs. 1 to 4. Devices for Comparing the Rotation of Shafts.

* See Engineering, vol. xcvi, page 459; vol. xcvii, pages 485, 821.

other colour. For large difference of speed the colour indicates the phase; then as difference is brought near to the vanishing amount, the relation of the marks m_1 and m—as already shown—becomes the determining factor.

CO_2 Recording Apparatus.

Mr. Naito, in his paper, explains that the principle of CO_2 recording is to relate temperature in a furnace with the ratio of CO_2 in the flue to volume of air supplied; excess of air obviously lowers the temperature and hence as long as sufficient air is available, the higher the temperature the higher the percentage of CO_2. He criticises existing apparatus, and proposes one as shown in Fig. 5. P is a water jet pump supplied with acidulated water; it sucks the gas from the flue and passes it into the reservoir C, where the gas collects at the top. Between C and the absorbing bottle E is a valve D, the absorbing element, placed in the lower division of E, consists of an alkali solution, and into this solution B, through its connection with the valve D, descends when D is opened. B is built up of thin strips of material non-corrosive to alkali, bound together at top and bottom. With valve open, and B in its lowest position, immersed in the alkali solution, this solution is shut off from the gas, the bottle being closed by the upper rim of B. In this position the gas passes through E without contact with the alkali and lifts the holder H until excess bubbles out at F; the rise of H measures quantity. Valve D is then closed, B being raised simultaneously so as to open the bottle of alkali solution; the latter acts on the CO_2 and absorbs it, H falling by the amount of the absorption. The ratio of the fall of H to its original height gives the percentage required by the operation.

Fig.5.

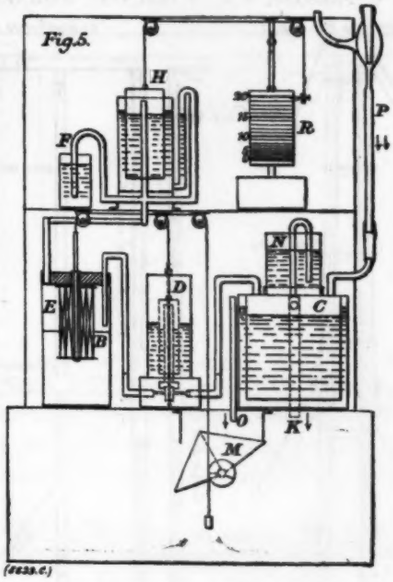


Fig. 5. CO^2 Recording Apparatus.

Fig.6.

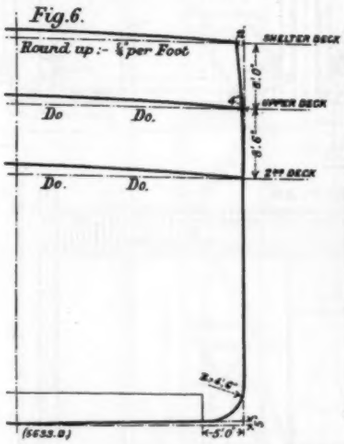
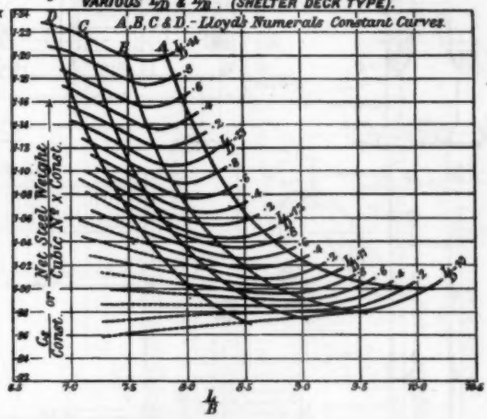


Fig.7. DIAGRAM OF STEEL WEIGHT COEFFICIENTS FOR VARIOUS $\frac{L}{D}$ & $\frac{L}{B}$. (SHELTER DECK TYPE).



Figs. 6 and 7. Weight Constituents of a Cargo Ship.

Weight Constituents of a Cargo Ship.

Mr. Hashiguchi's paper deals with a systematic investigation of the weights of cargo vessels of various types, dimensions and proportions, with a view to simplifying the work of selecting and determining the type and principal dimensions of a proposed vessel. He deals chiefly with the weight of steel, premising that generally speaking 81 per cent. to 84 per cent. of weight of hull of a common ocean-going vessel is made up of net steel. After careful investigation of reliable data he comes to the conclusion that total steel weight may be taken as approximately proportional to length multiplied by weight per foot run of material shown on the midship section. He has elaborated careful calculations based on this conclusion for shelter-deck steamers all 475 ft. in length between perpendiculars, in which the $\frac{L}{D}$ ratio varies from 10 to 14, and $\frac{L}{B}$ ratio 7 to 10. Particulars and proportions are given in the annexed table.

A typical midship section is shown on Fig. 6. Scantlings and arrangement of materials are taken exactly in accordance with Lloyd's printed rules; all the ships have three complete decks, with beams on every frame, channel frames of ordinary spacing, and intermediate angle frame in 'tween decks, usual hold stringers, complete double bottom, solid floors on every frame; frames, deck plates, and tank top all joggled. The results of the calculations are shown on Fig. 7; the ordinates of this diagram require to be multiplied by 0·3 to give Cs—the coefficient of net steel where:

$$Cs = \frac{\text{Nett steel} \times 100}{L \times B \times D}$$

Mr. Hashiguchi points out that the method of construction of the diagram must involve sudden jumps in the curves, these jumps being, however small in magnitude. While applicable directly to ships 475 ft. long only, Mr. Hashiguchi claims that Fig. 7 may be used also with care in the case of much shorter ships; he has applied its readings to ships 380 ft. in length with satisfactory results. Other investigations have led him to a figure relating weight of steel in a shelter deck ship to the weight in a full scantling three-decker; this ratio is 0·95 or 0·96; and, again, ratio (0·91) of a shelter deck ship with two decks (the so-called single-deck shelter decker) to the shelter-deck ship with three decks.

Passing to three-island ships he shows that net steel may be expressed by

$$a \,.\, C s_u \,.\, N_u + e\,(C s_b \,.\, N_b - a\, C s_u \,.\, N_u)$$

where

$N_u = \frac{L \times B \times D \text{ to upper deck}}{100}$ cubic No. to upper deck

$N_b = \frac{L \times B \times D \text{ to bridge deck}}{100}$ cubic No. to bridge deck

$C s_u$ and $C s_b$ = coefficients of shelter decker net steel appropriate to the two depths.

$a = \frac{0.91}{0.95 \text{ to } 0.96} = 0.95 \text{ to } 0.96$

e = ratio of combined length of erections to length p. p.

For items of hull weights other than steel, Mr. Hashiguchi finds cubic number multiplied by a coefficient of 0·06 to 0·08 correct, a slight difference arising between different types of ships. The paper proceeds with a comparison of the freight-earning qualities of shelter deckers and three-island ships, in relation to steel weight; Mr. Hashiguchi arrives at conclusions favourable sometimes to the one type, sometimes to the other. The data used for the purpose involve considerable difficulties and uncertainties, from which the foregoing portions of the paper seem singularly free.

Shelter Deck Type.

Length p.p.	Ind. Breadth.	Depth to Shelter Deck.	$\frac{L}{B}$	$\frac{L}{D}$	Frame No.	Plating No.
475	60·59	33·93	7·834	14	86·52	41,007
	63·54		7·474		89·47	42,498
	66·49		7·144		92·42	43,900
	69.43		6·841		95·36	45,296
	57·93	36·54	8·196	13	86·52	41,097
	60·93		7·793		89·47	42,498
	33·88		7·437		92·42	43,900
	66·82		7·109		95·36	45,296
	54·93	39·59	8·648	12	86·52	41,097
	57·88		8·208		89·47	42,498
	60·83		7·809		92·42	43,900
	63·77		7·449		95·36	45,296
	47·02	47·50	10·100	10	86·52	41,097
	49·97		9·506		89·47	42,498
	52·92		8·974		92·42	43,900
	55·86		8·504		95·36	45,296

REINFORCED CONCRETE RESERVOIR, MONTEVIDEO.

(*Concluded from page 455.*)

It was decided by the Montevideo Waterworks Company to construct the reservoirs according to the designs which have been described in our previous article, by administration, under the direction of the Hon. R. C. Parsons, and not by contract. The construction of the works was commenced in October, 1914, and the contracts for the steel for the reinforcement bars were placed in the month of March, 1915, and the bars shipped before the very stringent war regulations came into force.

Although the designs of the reinforcement were prepared on the supposition that the bars were to be round and of mild steel, it was impossible, owing to the exigencies of the war, to provide this class of steel throughout, and it was necessary to make use of what is technically termed "shell steel discard" in some cases, and in others high-tensile indented steel bars manufactured in the United States of America. All the bars were maintained accurately in their specified positions with binding wire, so as not to be displaced during the process of ramming the concrete, which is so essential in reinforced concrete work. In order to obtain the necessary union between the bars and the concrete they were in some cases crooked at the ends and in others the ends were split and bird-mouthed.

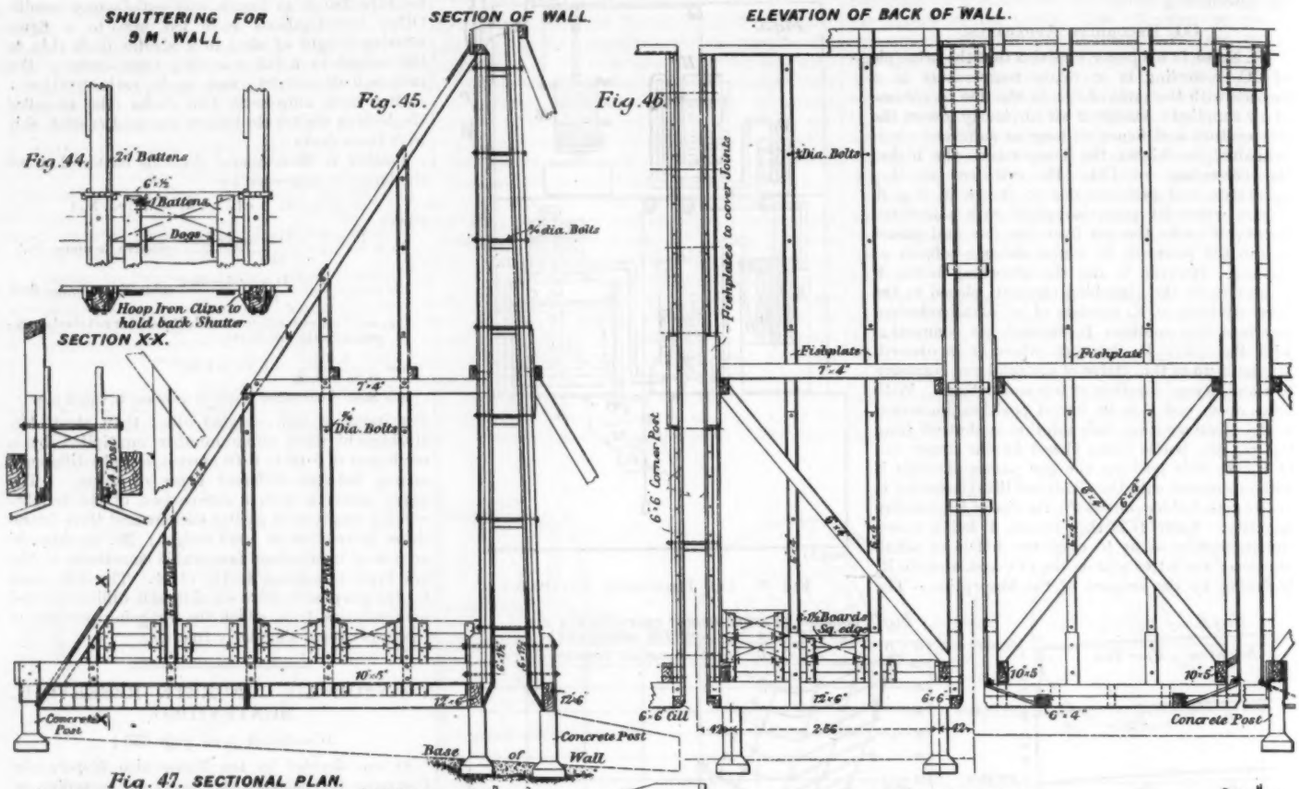
The Portland cement used in the structure was exclusively of British manufacture complying with the British Standard Specification No. 12, revised in August, 1910, and being of the slowest setting quality referred to in Clause No. 7 therein. The concrete used in the several parts of the work was composed as follows:—

The floors	...	1 cement, 2½ sand, 4½ broken granite, 2 in. maximum cubes.
Base of walls	...	1 cement, 2 sand, 4 broken granite, 2 in. maximum cubes.
Walls	... ...	1 cement, 2 sand, 3 broken granite, 1 in. maximum cubes.
Columns and girders		1 cement, 2 sand, 3 broken granite, 2 in. maximum cubes.
Roofs	...	1 cement, 2 sand, 4 broken granite, 1 in. maximum cubes.

The broken stone was hard granite derived from

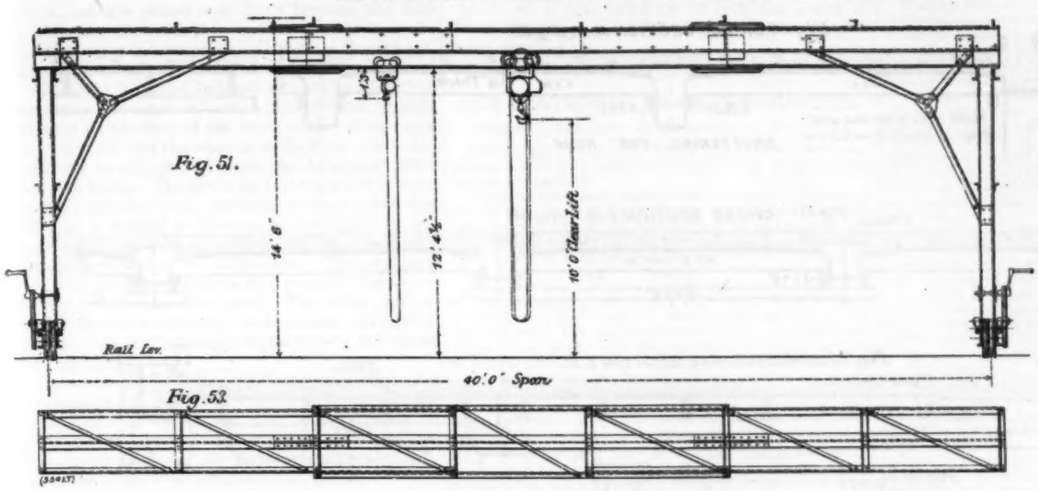
REINFORCED CONCRETE RESERVOIRS AT MONTEVIDEO.

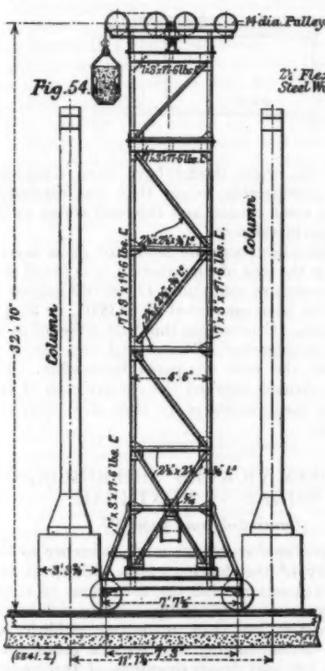
THE HON. R. C. PARSONS, M.A., M.INST.C.E., ENGINEER, LONDON.

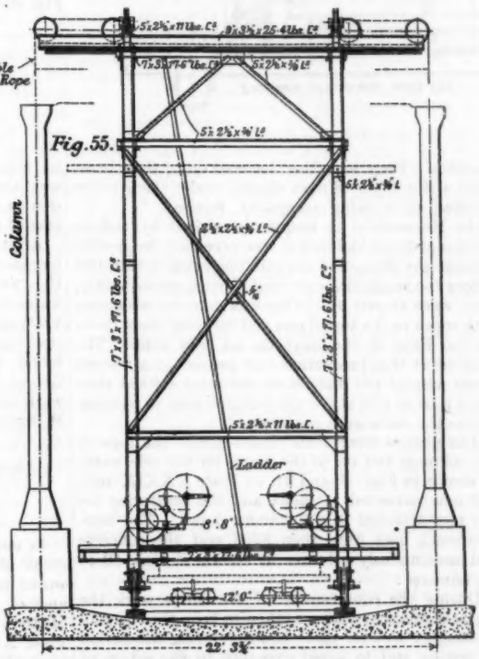


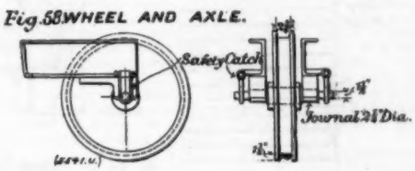
REINFORCED CONCRETE RESERVOIRS AT MONTEVIDEO.

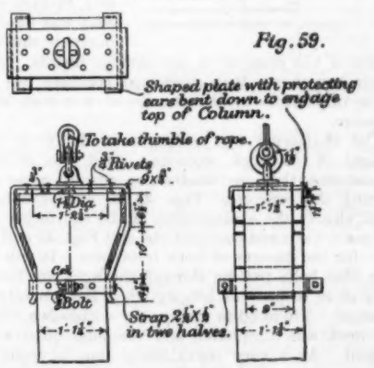
THE HON. R. C. PARSONS, M.A., M.INST.C.E., ENGINEER, LONDON.

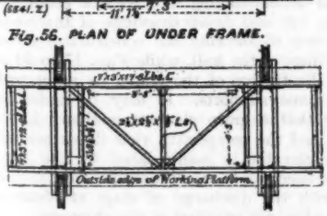


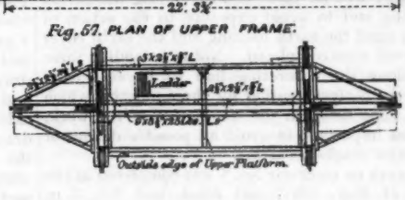







LIFTING CAP FOR COLUMNS.
Fig. 59.
Shaped plate with protecting ears bent down to engage top of Column.
To take thimble of rope.
2 Rivets 9/8".
Bolt
Strap 2½"x½" in two halves.





a quarry in close proximity to the site of the reservoirs, and was broken to the required size in each case by means of stonebreakers. The sand was sharp and of good quality, brought to the site of the works from a distance of 25 miles.

As it was considered to be essential to ensure the solidity of the structure that the concrete after it was mixed should be placed in the work in the least possible time, care was taken to locate the concrete mixers in a convenient position and to lay portable tram roads to convey it to the required points, from which in some cases it was raised by derricks on to the work. The groups of men employed to raise and ram the concrete were also carefully organised, and the result obtained was that the interval of time which elapsed from the concrete leaving the mixer to its being completely rammed, did not exceed three-quarters of an hour. The work proceeded without intermission during the working season by means of two shifts of 8 hours each, and no interval from one day to the next was allowed to be more than nine hours.

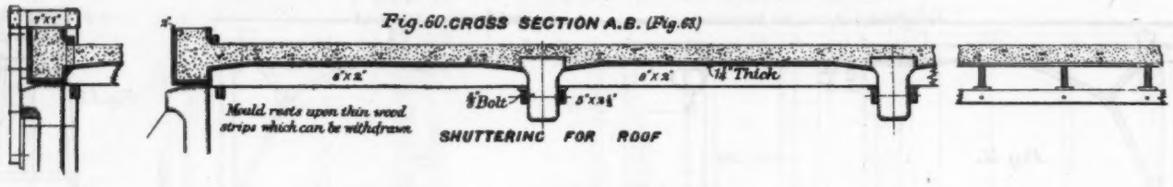
All the cement was carefully tested before it was shipped and, further, each batch of cement was re-tested 28 days before it was used in the work so as to ascertain whether any loss of strength had occurred during transit or in the interval of its being stored at the site of the works. Should such diminution of strength be detected, then additional cement according to a definite scale was to be added so as to restore the strength of the concrete to that which had been deemed necessary, but only in one instance was this precaution required.

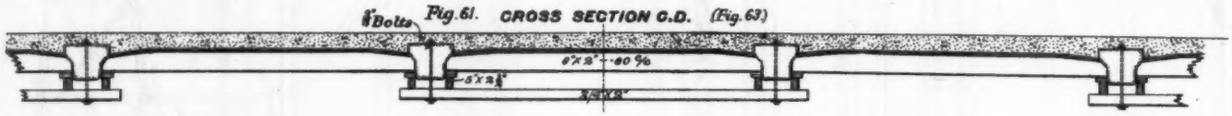
It was considered that if the precautions which have been explained were strictly observed that a concrete sufficiently impervious to the passage of water could be secured without the use of any of the various substances which are advocated to obtain this result. As a further precaution, during the progress of the work the following tests were carried out with the view of ascertaining how the imperviousness of the concrete to the passage of water at high pressure varied with age: A cast-iron pipe was plugged with concrete 12 in. thick, composed of 1 cement to 2 of sand and 3 of stone, 1 in. maximum cubes, being the same proportion as that used in the walls, and subjected to a pressure of 5 lb. per square inch after being allowed to set for six days, it was found to be very porous. The sample was then allowed to remain thoroughly wet for another 14 days, when with 10 lb. per square inch pressure there was considerable improvement, and when the sample was 4½ months old there was no sign of leakage with 40 lb. pressure after 8 hours.

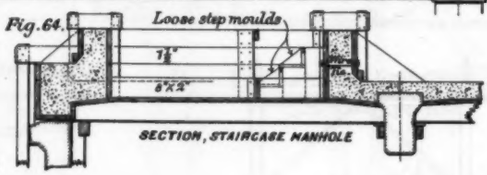
It was therefore decided that there was no necessity of incurring the expense of rendering the inside of the reservoirs, consequently, much care was observed in the construction of the shuttering

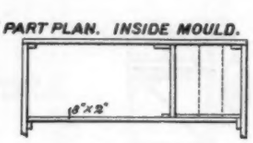
REINFORCED CONCRETE RESERVOIRS AT MONTEVIDEO.

THE HON. R. C. PARSONS, M.A., M.INST.C.E., ENGINEER, LONDON.









so as to obtain as smooth a surface as possible, and, further, soft soap was used to prevent the adhesion of the cement to the shutter boards. The result has shown that reinforced concrete can be made impervious to the passage of water at high pressure.

The shuttering was arranged in detail as the designs of the work proceeded, as it was of first importance that no hindrances should occur in placing the concrete. Figs. 44 to 48, page 516, show clearly the arrangement of the shuttering for the main walls and counterforts, and Figs. 49 and 50 that for the corners of both reservoirs. It will be seen that bolts passing through the work are freely used so as to prevent bulging when the concrete is rammed. These bolts were easily withdrawn when the work was completed, and the holes filled with cement. As a very considerable sum is required to cover the cost of shuttering in all ferro-concrete work, the designs were prepared so that the timber could be used more than once, and in the present case this was done as often as possible, but in no case was shuttering removed without an interval of two weeks being allowed for the setting of the concrete. As a result the shuttering was, on the average, used twice over. Great care was observed to ensure the reinforcement bars being free from any greasy substance which would prevent the cement adhering to them.

The columns of both of the reservoirs, and also the girders, were constructed partly on the floor of the reservoirs and the remainder in a block yard near the site, where a travelling Goliath (see Figs. 51 to 53, page 517) was provided for lifting them when being stacked and for placing them on the trucks for conveyance to the reservoirs for erection. As the placing of the columns on their bases and also the laying of the girders across their tops required to be carefully and accurately done it was necessary to provide a special lifting apparatus for the purpose, which is shown in Figs. 54 to 58, page 517. It will be seen that this traveller, which moved on rails between the rows of bases, is capable of placing two columns at the same time. The columns when they reached the site had a lifting cap, shown in Fig. 59, page 517, attached to the top, and were raised from a recumbent position on two trucks to a vertical position. They were then lowered on to their bases with a thin layer of neat cement under them which ensured their being accurately vertical.

As Montevideo is frequently visited by sudden storms of great violence it was necessary to provide against any danger of the columns being overturned before the reservoirs were roofed over, consequently, they were stayed up. This was done by attaching wire ropes to the top of one and carrying them down to the base of the next on all four sides. The wisdom of this precaution was proved as a violent storm visited the district at the most critical time when a large number of the columns were in position before the roofs were constructed.

The girders were then placed across the tops of the columns and on to the plates on the side walls, as shown in Figs. 30 and 31, on Plate XXXIX *ante*, but not connected to them, and the shuttering for the roof attached in the manner shown. The reinforcement bars were then fixed and the concrete laid continuously all over as shown in Figs. 60 to 65, annexed.

During the construction of the entire work the greatest precautions were taken to keep the concrete thoroughly wet for three months during the period of setting and to avoid exposure to the action of the sun until the earth backing and the earth cover to the roof were completed. Notwithstanding these precautions the concreting had to be suspended during the hottest weather for three months, which caused some delay in the completion of the work, as it was important to avoid all possible danger of contraction cracks occurring.

The work on reservoir No. 4 was completed in the month of May, 1917, and filled, and No. 5 in November, 1917, and filled. Very careful investigations were made as to their tightness, which showed that they bore the test very satisfactorily, the leaks being very small and after a short time these were reduced to 1½ cub. ft. per minute. Since then they have been growing less, and should ultimately cease entirely.

On page 528 are given, in Figs. 66 to 69, reproductions of some photographs taken during the progress of this work which clearly illustrate the procedure adopted. The cost of the entire work has been considerably augmented owing to the high freights on materials imported, the enhanced cost of materials obtained in this country and also locally, due to the war, and further the rise in the price of labour due to local legislation. The period in which the work should have been completed was also considerably longer than was estimated, due to the same causes, and this also added to the cost of superintendence.

After due allowances are made for these several increases in the cost of construction, it is found that the two reservoirs containing 13,000,000 gallons of water would have amounted to 65,000*l.*, or 5*l.* per 1,000 gallons. Contrasting this with those of other reservoirs constructed of reinforced concrete it is found that the cost compares favourably. Mr. George E. Arnold directed the construction of the work under the direction of the Hon. R. C. Parsons, M.Inst.C.E.

CANADIAN VICKERS' SHIPBUILDING WORKS AT MONTREAL.

(*Concluded from page* 397.)

In our previous article we made reference to the great utility of the floating crane utilised at the works in connection with the fitting-out of ships and of repair work generally, and in fulfilment of the promise we then made we publish on Plate XLI accompanying this issue a perspective view (Fig. 14) and detail drawings of this crane, Figs. 15 and 16 showing the constructive details and scantlings of the hull, while Figs. 17 to 20 are drawings illustrative of the crane, its roller path, and the crane supports. It may be added incidentally that a grain elevator is shown in the drawings, and the perspective view illustrates how the grain elevator is manipulated by the crane when it is used, as is sometimes the case, in connection with the discharge of ships at Montreal Harbour, when not required at the shipyard.

The hull or pontoon has a length moulded of 200 ft. 5 in., a moulded breadth of 43 ft., and an extreme breadth of 43 ft. 10 in., while the moulded depth is 10 ft. There is a centre-line bulkhead between the end bulkheads, as shown in Fig. 16. Strongly-built girders, well supported by deep floors are fitted on each side, to resist the strains set up under the varying conditions of working. Six transverse bulkheads are fitted, and the necessary store-rooms, &c., are placed in the hold of the pontoon between these bulkheads (Fig. 20). A strong elm fender is fitted all round the pontoon at the level of the deck, securely bolted between angles. A walking gangway of white pine is fitted all fore and aft on the top of the floors on each side

of the pontoon. A rudder, worked by hand gear, is also fitted. The pontoon is well cement-washed on the inside and suitably drained for pumping out. In order to ensure the safety of the crane, 300 tons of ballast are placed well down between the floor plates, and distributed in such a manner that the weights upon the structure will be even throughout, and thus avoid undesirable straining.

Specially arranged balance weights are fitted to minimise the angle of heel. One of these weights is fixed on the base of the crane on the side remote from the jib, and the other is in the form of a truck, and can be adjusted to assist the balancing under varying loads. The lower part of the crane is fixed to the revolving table, which has a range of 360 deg. The jib is hinged at the top of strongly-built uprights, and can be adjusted by means of a connecting-link girder attached to a large screw. The centre-pin is of massive proportions, and strongly connected to the structure of the vessel. The roller path on which the crane revolves is well secured and bedded to the deck, and strongly supported by bulkheads and girders.

The crane is proportioned for handling a maximum working load of 75 tons at a radius of 51 ft.; 60 tons at a radius of 66 ft., and 10 tons at a radius of 72 ft., the minimum radius of the crane being 40 ft. The height of lift is 100 ft. above the water-level when the crane is working at 51-ft. radius.

Four motions are provided, viz., hoisting, derricking, slewing, and ballast adjusting. Two sets of double-cylinder horizontal steam engines are provided for working the above motions (Fig. 18), one set with cylinders of 9-in. bore by 18-in. stroke for hoisting and derricking, and one set with cylinders 8½-in. bore by 12-in. stroke for slewing and ballast adjusting. The hoisting gear consists of three reductions of steel spur gear. The load is lifted on eight parts of extra-flexible best plough-steel wire rope, winding two parts, the drum being grooved right and left hand. Change gear is provided on the hoisting motion in order to give three speeds of lift. The derricking is worked off the second-motion hoisting shaft by means of one further reduction of spur gear, one bevel gear and a large screw, working into a gun-metal nut fixed to a swivelling crosshead attached to the lower end of a steel link, the upper end of which is connected to the back end of the jib.

The crane revolves on a set of live rollers (Figs. 17 and 19). The bottom roller path is a complete cast-steel circle, having teeth on the outside, with which the slewing pinion engages. The slewing gear consists of two bevel-gear and two spur-gear reductions (Fig. 18); two speeds are provided.

The ballast-adjusting mechanism includes one bevel-gear and one worm-gear reduction. The travelling counterweights on each side of the crane are racked in and out by means of flat-link chains working on sprocket wheels.

The crane structure (Fig. 17) consists of a revolving turntable carrying a double triangular frame, on the apex of which the jib is pivoted, The jib is a lattice structure, having two bottom booms and one top boom, forming a triangle.

The various motions are controlled from the driver's cabin, which is situated in an elevated position in front of the crane. The speeds at which the various motions can be performed are as follow:

Hoisting	...	75 tons at 3 ft. per minute.
Hoisting	...	25 tons at 9 ft. per minute.
Hoisting	...	10 tons at 20 ft. per minute.
Slewing	...	75 tons at 1 revolution in 4 minutes (slow gear).
Slewing	...	10 tons at 1 revolution in 2½ minutes (fast gear).
Derricking	...	From maximum to minimum radius in 8 minutes.

Steam is supplied to the engines at a pressure of 80 lb. from a large vertical boiler situated on the pontoon, with a steam pipe led up through the centre-pin of the crane.

The grain elevator, which is portable and self-contained, is fitted with a bridle to suspend the apparatus from the hook of the floating crane when required. The grain elevator is worked by an electric motor, and has a capacity of 80 tons of grain per hour. A dynamo is supplied and fitted suitable for supplying power to the grain elevator and for the electric lamps with which the pontoon and crane are fitted up. Two arc lamps are also fitted on the deck of the vessel.

The pontoon has a powerful steam warping capstan, and all the usual fittings for this class of vessel. It is also fitted up to fulfil the Board of Trade requirements, a lifeboat and other accessories being supplied.

THE INSTITUTION OF CIVIL ENGINEERS.

Address of Sir John A. F. Aspinall, *President.**

Gentlemen,—I have to thank you for the very great honour which you have conferred on me in appointing me your president.

While meeting here again on the occasion of a change in the chair, we all have in our recollection the large number of our members who have gone to the war, who are fighting for our homeland and those dear to them, and think with sympathy and regret of those 291 members who have made the great sacrifice.

The majority of our young men who form the backbone of the Institution will in due time come back to us to re-enter into the work of their profession in a civil capacity, and it is the duty of those who are left behind to see that when they do return every possible kind of help is given to them to make a fresh start, and assist them to forget the perils and privations they have gone through, also to afford those facilities which are necessary for them to maintain the engineering traditions of the Empire.

In the earlier days of the war the military authorities were quick to seek the advice and assistance of the Institution in obtaining officers of proved professional training for the engineering units in France and other theatres of war; and it has been our privilege to feel that confidence in the merits of our system of selection left no doubt in their minds that the right men were selected in every case in which the Institution was concerned. We also have reason to be proud of the engineering work which has been carried out by those who joined the forces, confirming as it does the knowledge that professional training of an adequate kind is the only road to success.

The number of our members attached to the fighting forces of the Empire since August, 1914, was on the last count 3,007. Their efficiency as soldiers is testified by 307 military orders and distinctions already gained by them. The recognition by the military authorities of their technical qualifications, largely influenced by their membership of the Institution, is shown by the fact that 1,430 of them have been commissioned as officers of the Royal Engineers—a number which would have been largely exceeded had the demands of the War Office for technical officers been in earlier days sufficient to absorb all the young engineers who offered their services to their country.

We cannot speak so favourably of the action of the Civil Departments of the Government, which have not always recognised the necessity for application to the heads of the engineering profession for men to deal with the emergencies which have arisen and to fill the very numerous posts connected with engineering construction at home; and it is not unreasonable to suppose that where works constructed under Government auspices have not been successful, better results would have been obtained had more attention been paid to the selection of men who were properly qualified to direct them.

I may perhaps be pardoned for reminding you of the important letter which was sent to the Prime Minister of the time by Dr. W. C. Unwin, when he was president in 1912, dealing with this most important subject of the fuller recognition of the advantages of professional engineering qualifications by Government Departments. This is a subject which must always be kept before us, and it is the more necessary that all our new members should feel that it is not only an honour to belong to the Institution, but an advantage as well. A man who bears the hall-mark of membership has the right to feel that his qualifications entitle him to consideration and support when dealing with public work or with those in Government Departments who control it.

It is gratifying to know that there is a large and continuous stream of applicants to join our Institution, although we are at war, and this may be an indication of the fact that it is becoming more and more evident how much the world is dependent upon engineering effort, whether applied to the destructive agencies of war or to the arts of peace.

On all sides we have seen that the work of our mathematicians, our chemists, our physicists, our metallurgists, and our electricians, has contributed to the successful prosecution of the war both by land and sea, and there seems to be a general recognition of the fact that all engineers' work must be given credit for our rapid progress in defeating every hostile invention.

It is good evidence of the deepening interest taken in all matters with regard to the concentration of engineering effort, that a number of the engineering and scientific societies which have not as yet got homes of their own are discussing the possibility of housing them all in one common building with common library facilities. It has been our privilege in the past to offer these societies the hospitality of our lecture theatre for their meetings; but I am sure that, though we shall miss their friendly visits, our members will be only too happy to wish them success in their new venture if it matures, and express the hope that Westminster will become the centre of their efforts.

I propose now to pass on to some of the points which, it appears to me, we will have to consider in connection with transport, with a view to its improvement when we are fortunate enough to be able to settle down to the active pursuit of commerce.

It is but little known that the question of the operation of the railways in the case of any great national emergency either at home or abroad, had received the unremitting attention of a carefully selected Committee of Railway General Managers in combination with the interested Government Departments during 1912 to 1913, and that every detail of importance had been thought out with the greatest care. When the unexpected happened, and we found ourselves at war, a few telegrams to the members of the committee brought them together to make use of already well-considered plans, which resulted in the rapid transportation and punctual delivery of troops at the port of embarkation, and their transmission across the Channel. How well that was done is a matter of history.

Since those early days the railways have been controlled by the Railway Executive Committee, whose efforts have been successful in making the fullest use of the existing railway staffs over the whole country. The result has been that the immense amount of travel and carriage of material has been directed and conducted with a very small staff, and work has been carried on by those who knew their business and were not prepared to tolerate mistakes.

The deadening effect of Government operation of industry has not been felt on the railways as it has been on other great interests, and this has been largely due to the work not having been taken out of the hands of those familiar with it.

I allude to this earlier history of the absolute control of the railways by an executive committee because, as the weary years of the war have been prolonged, this unification of effort in dealing with the nation's transport has led many minds to consider what is to happen after the war. Any changes which take place will in many ways affect the interests of engineers, and it is therefore well to look ahead and speculate, if you will, on the possibilities of improvements, and how those of us who are concerned in the construction of new railways, or those who are interested in the great engineering manufactures used by railways, are likely to be affected by such changes, or by any radical upheaval of present methods, if such are likely to come.

It is in devising methods for securing a greater output and creating machinery to take the place of hand labour that the efforts of our engineers must be directed, if we are to reduce the cost of transport and help ourselves to compete with the manufacturing instincts of competitive nations. The railways, as great users of materials, will find the burden of increased costs, when added to the labour charges, to be so great that it will become more than ever necessary to see how operating costs can be reduced and how far mechanical processes can eliminate hand labour, not only with the object of getting rid of unnecessary toil, but to get more work done in the same time for less money.

The most important engineering question to be faced, in my view, is the necessity for considering what can be done to increase the structure gauge on our railways. The capacity of our rolling-stock is hampered in an extraordinary degree by the fact that, as pioneers of railway construction, we could not in the earliest days of railways appreciate what the immense growth of railway requirements would be, and what would be the dimensions of the loads we should be asked to carry, or the weight per wheel which our bridges would have to bear.

The "structure gauge" limits the "loading gauge," which in turn limits the exterior dimensions of our rolling-stock, whilst low bridge-strengths prevent progress with the use of heavier and more powerful locomotives. The difficulties of altering the structure gauge are greatest with the small tunnels, though fortunately these are not very numerous, but we have many platforms which prevent the widening of any part of our rolling-stock at a height of about 3 ft. 6 in. above the rails, while there are numerous girders standing up between the lines of rails which are in the way, and there are many other points of obstruction which have rendered the restrictive list of "loading gauges," issued by the Railway Clearing House, an absolute necessity for safe loading.

It is an extraordinary fact that on the British railways there are no fewer than 66 different loading gauges applicable to 150 sections of lines, all of which have to be taken into account when considering the forwarding of rolling-stock, and the obstructions which exist on railways and dock properties which have sidings of their own.

According to the Board of Trade Returns, there are in England, Scotland and Wales, about 100 large and small separate railway companies with a 4-ft. 8½-in. gauge, but I find that the maximum number of railways which can accept loads of one of the largest, though not the largest, loading gauge, is 18. Some of our larger railways have, through a course of years, steadily improved their lines to get rid of these difficulties, but the wider and longer rolling-stock, whether locomotives, carriages or wagons, which they can use has to be confined to their own property and cannot be allowed to pass everywhere.

The extreme dimensions over the cylinders of outside-cylinder locomotives have been reached on account of these obstructions and render it difficult to design a more powerful locomotive constructed in this form, though there are several forms of multi-cylinder engines which evade this difficulty at the expense of a multiplication of mechanism. The possibilities of an extension of electric traction would, however, render it less necessary to deal with many platforms, as electric locomotives such as have already been designed can haul loads far beyond

* Delivered November 5, 1918.

anything we handle in this country, though their exterior dimensions at platform level would not foul our largest loading gauges.

We have had recent experience of the impossibility of dealing with French rolling-stock on this side of the water, although the track gauge is practically the same, while our smaller English stock has been daily able to travel on the ferries and pass on to the French railways. Rolling-stock of the International Continental type could not pass many of our "structure" dimensions, and thus if that urgently needed great work, the Channel Tunnel, were completed we should be in the position of having either to send stock through it which did not suit foreign railways, or receive stock which did not suit us. It would be of little advantage to send goods from the Continent to the end of the tunnel if they had to be transhipped into a British truck, and double handling had to be paid for.

Surprise is often expressed that we do not use the long bogie-wagon of American type in this country to increase our carrying capacity and reduce the tare. Strenuous efforts have been made on several of our lines to carry this out, but the British trader's habits have always defeated the successful use of such vehicles, except for the heavier and low-value classes of goods or minerals. The trader has grown so accustomed to ordering what he wants in very small parcels, and having them sent in the afternoon to a railway station with the expectation of seeing them delivered with the regularity of a postal etter at his place of business the next morning, that he will not tender anything like a reasonable wagon-load. It has become a question with him of credit from his bankers, and he will not hold a pound of stock more than is necessary to carry on his business, especially in the case of high-priced merchandise.

On the Continent the existence of a difference of railway charges for slow-speed and fast-speed trains has led the trader to accept the delay necessary to get full wagon loads of a mixed character, but legislation as to charges in this country does not admit of such arrangements.

It seems probable, as a consequence, that if we get our "structure" gauges altered we shall have to be content with a longer four-wheeled wagon of the Continental railway dimensions rather than a longer vehicle carried on two bogies, though an alteration in legislation as to graduation of carriage charges based on speed would have more effect on the construction and use of high-capacity wagon-stock than any exertion by the railway operating staff to increase its use.

Such a large proportion of the goods to be carried in this country are bulky, rather than weighty, that we undoubtedly require that the bodies of our wagons shall be of greater internal cubic capacity, and we want more width, and, if possible, more height, in order to get these light goods as nearly as possible up to the weight-carrying capacity of the wagon, while other classes of rolling-stock should be given more room to expand, and every exertion should be made to reduce the tare weight.

Great improvements can be made in the structure gauge without in any way altering the 6-ft. space between the lines of rails. The structure gauge is at present not only the main difficulty in the way of further improvement, but also of the standardisation of rolling-stock, including locomotives, and I am sanguine enough to hope that any change which may take place in the ownership of railways will lead to an active policy of enlargement of this limiting gauge, which would probably not cost more than a few days of war expenditure, but which would, in the end, materially add to our railway efficiency. It is really a national matter and should be carried out at national cost.

In connection with the possibility of a more complete standardisation of locomotives, one often hears comments on the question of the variety of types of locomotives used upon British railways, but when one gets down to solid discussion, one finds that the speaker is generally referring to classes and not to types. The types are very much the same on all our railways.

Having determined the types, it is very often necessary to have more than one class of the same type. For instance, an express passenger engine of the 4-4-0 type for hauling the heaviest long-distance trains may be quite unsuited for stopping trains, and another class of the same type may be necessary on the same length of railway, though many of the working parts may be exactly the same. We thus have two classes of the same type, but each made to fit the work required in such a way as to produce the greatest economy.

Any large railway will probably require a number of types such as:—

An express passenger tender engine,
An ordinary passenger tender engine,
A passenger tank engine for local trains,
A fast goods engine,
A heavy coal or goods engine,
A powerful shunting engine,
A shunting engine for light work,

each of which would be indicated by its wheel arrangement; and in special cases, other types may be required. This list means that at least seven types are wanted, and if the line traversed has many heavy gradients, these types may be split up again into various classes to enable them to deal with the work at all parts of the line without reducing loads.

If, however, we assume that the line of railway does not vary, and that the seven types will do all the work, the question of maintaining those types for a long period of years, always assuming that they have been thoroughly well designed—depends on the march of progress. If you look back over a series of years, you will find that each period of, say, ten years on some lines, and fifteen years on others, calls for great changes in the locomotive brought about by changes in traffic conditions, when it becomes necessary to break away from tradition and to enlarge and improve the machine as a whole, while retaining the maximum possible number of interchangeable parts.

If we take the period of ten years, and assume the life of the locomotives to be thirty years, it is obvious that after the tenth year, if such changes as I have indicated come about, we shall be adding to our number of classes, and may even have to add to our number of types, and that before the actual death-rate of the first lot, due at the thirtieth year, really begins, we may have 21 different classes or types on the same railway at the same time. The casual observer might consider that there was too great a variation, whereas the user would be easily able to show that progress has demanded the change, and that economy of operation and capacity for earning have been increased by the modernisation of the plant. The change, therefore, becomes a subject for commendation, and not for superficial criticism.

The form of the locomotive, as distinguished from its original detailed parts, may last for thirty years. Generally speaking, however, early renewal of rolling-stock is the true economical policy, and machinery should be kept absolutely up to date. A railway is not a museum for retention of old machinery, but a highly organised implement of commerce, and to be efficient must progress.

Duplication of parts in manufacture and absolute interchangeability of parts in maintenance are two of the greatest sources of economy with all machinery. The first reduces the original cost, while the second enables rapid construction or repairs to be carried out and reduces the stocks of costly stores.

A railway company must be capable of effecting very rapid repairs to its locomotives, and duplication saves time and money. The larger the company, the greater the capital rendered idle if numbers of locomotives are standing waiting repairs. As matters at present stand, each of the railway companies being on an independent basis, their locomotive stock has been designed to suit their own special requirements, and within each company-worked area they have built up an admirable system of duplication, which it would be very costly to change.

If, however, the railways are taken over by the State, or amalgamated in some other form, about which nothing is at present definitely determined, then it is probable that there will be an arrangement to limit the designs of engines to such a number as will do the work in any part of the country, no doubt retaining as far as possible each set of engines on existing routes until they require renewal, as a measure of economy to use up available stores and spare parts in the most practical way, when the selected designs, not necessarily new designs, will replace them; but it will be appreciated that the transition period, extended over, say, twenty-five years, will be a very expensive one, as the money to be saved on new construction will be trivial, and will be much more than wiped out by the interest on the greatly increased value of stores at workshops and outdoor locomotive sheds, necessitated by the introduction of new parts. This is, in a measure, due to the fact that the number of new locomotives required in one year in this country is comparatively small, and even that number will become less as electric traction extends.

The work which has been going on for years on all the larger railways to reduce costs by the standardisation of parts, has not been appreciated at its true value. The railways have, going back for many years, been the pioneers of standardisation, and have reduced the interchangeability of parts to a fine art. The money value of interchangeability of parts is immense, and the reduction of stocks of stores at outside locomotive running sheds, and rolling-stock repairing establishment which has resulted, represents a very large capital sum.

A Committee of Railway Locomotive Engineers and Carriage and Wagon Superintendents has been sitting and investigating every point in connection with the further standardisation of railway rolling-stock during the past two years or more, and an immense amount of most valuable work has been recorded and tabulated with a view of seeing how far it is possible to arrive at a common agreement. The progress in agreement has been remarkable, but the general result so far has been that it became evident at a very early stage that the great bar to progress and uniformity in increasing overall dimensions within commercial limits was the existence of the very varying structure-gauges on British railways, and the difference in the carrying capacity of bridges.

To make locomotives, carriages, or wagons of such dimensions, as regards the whole machine, as to enable them to go anywhere, was soon found to involve the reduction of dimensions of all three classes of rolling-stock on many of our important lines, representing a retrograde policy instead of a progressive one.

With regard to carriage stock, great downward changes would, under present conditions, have to be made. One of our greatest railways, for instance, would have to be content with vehicles 57 ft. long and reduce the width over the body, while at present they have many vehicles 70 ft. long. Another, whose electric stock measures 60 ft. long and 10 ft. over the body, would have to sacrifice a large carrying capacity to conform to the rigidity of a universal standard. On the other hand, there is nothing to prevent a more complete standardisation of running gear and brake work.

So far as the metal frames of steel or iron are concerned, either for carriages or wagons, the British standard sections are being used to the exclusion of those of old dimensions.

It cannot be expected that those railways which have progressed on modern lines, and have increased their earning capacity per train-mile by the use of the largest permissible rolling-stock, should go back to smaller and less efficient plant merely for the sake of theoretical standardisation of form. Hence the necessity of the very bold policy of sweeping away all fixed structures which are now in the way, and altering all bridges which are too light, being carried out to enable the smallest rolling-stock to be brought up to the highest standard.

This general question has been exercising the minds of our American friends since their railways were controlled by the State, and it is illuminating to read the views of Mr. Alba B. Johnson, the president of the Baldwin Locomotive Works—the greatest private locomotive works in the world—who puts, in a few pithy sentences, his views on the situation in an address which he delivered to the Annual Convention of the Chamber of Commerce of the United States of America, in Chicago, in April of this year. I make no excuse for repeating some of them here.

Mr. Alba B. Johnson says:—

"The increase in car loading reduced the number of cars which could be hauled per train, and resulted in a demand for larger locomotives capable of hauling no less a number of cars than before. This found its limit in the capacity of rails and bridges to sustain the increased axle loads. Again and again rails and bridges have been replaced to permit of the constantly increasing axle loads from 10 tons to 15 tons, from 15 tons to 20 tons, from 20 tons to 30 tons,* and finally to about 35 tons, the present maximum. If we stop to consider for a moment what this has meant to the industry of the country, we will realise that each change has involved practically the total replacement of rails, bridges, cars and locomotives on existing lines throughout the whole country, and each step has resulted in a reduction of the cost per ton-mile until the cost of transportation in the United States has gone far below that attained in any other country.

"Standardisation has been an ideal much-talked of but never realised in actual practice, because standardisation implies the crystallisation of present practice as the practice of the future.

"The result of more than eighty years of experience has convinced railroad men that the most advantageous field for standardisation is in details rather than in the complete locomotive or car as a unit.

"We should therefore look carefully before we leap, to make sure that we are not giving up the substance of continued growth in efficiency and economy, to grasp the chimera of standardisation."

In confirmation of Mr. Johnson's views I find that the growth of locomotive power during fifteen years in the United States is indicated by figures recently published,† which show that in 1900 there were 36,600 engines with single-expansion cylinders having an average tractive power of 19,000 lb. and an average weight on drivers of 85,000 lb., whereas in 1915 these figures had become 62,000 in number, with an average tractive power of 30,500 lb. and an average weight on drivers of 135,000 lb., without taking into account compound engines or Mallet engines, of which latter there were 800 with an average tractive power of 79,000 lb. and an average weight on drivers of 350,000 lb. These figures represent an immense increase in commercial capacity for haulage, and point to the fact that there must have been a great reconstruction of bridges to carry the increasing weights per wheel.

In pressing forward the all-important question of the further standardisation of parts, nothing should be done to prevent the acceptance of new ideas which tend towards the improvement of conditions and the economy of operation, though a nicely-balanced judgment will often be required to decide between the acceptance of some excellent new idea and the economy to be maintained by the retention of parts which are absolutely interchangeable.

In the world of mechanism there can be no finality, and we ought not to look forward to finality if we are to keep pace with other nations. The brightest ideas of many minds may easily be killed by over-standardisation, and one has but to look at the motor-car industry, to see how the inventive brains of many of our countrymen have been stimulated by the varied requirements of motor travel to produce some of the most beautiful mechanism in a number of forms, many of special engineering merit.

One trembles to think how the too enthusiastic theoretical standardiser could in this case have put a stop to practical progress, and sterilized the best efforts in this great modern industry, while the well thought-out standardisation of many details and minor parts has helped the manufacturer to purchase parts in a competitive market. Once, however, any one great manufacturer has determined that his form of mechanical product can safely be produced in quantity, perfect standardisation of all details is the only road to commercial success.

Another matter which seriously affects railway economy is the character of the appliances at our seaports, as inefficient appliances for handling goods and minerals not only put up the cost to the consumer but cause serious delay to rolling-stock.

Strong comments have been made by some of the recent Government committees upon the want of mechanical appliances at our seaports for the unloading and loading of ships, and it cannot be denied that there is a large field for the mechanical engineer in providing up-to-date appliances of a varying kind to suit the trade of each port. Some of the largest ports are said to be the most deficient in handling appliances. There is the less excuse for this nowadays when the possibility of the purchase of electrical power enables machinery to be placed in almost any position.

It must, however, be remembered that the problem of

* American tons are 2,000 lb.

† The Journal of the American Society of Mechanical Engineers, July, 1918, page 656.

unloading or loading ships is by no means the easy matter which some people suppose, and the very difficulties—not of a mechanical nature—make it the more necessary to have quick and cheap handling of the goods so that every farthing per ton can be saved in manipulation, and quay space, which is always costly, can be rapidly cleared. Our Customs regulations require the examination of imported goods, and nearly everything taken out of ships must be put down on the ground to be looked at, and this alone necessitates double handling.

Our exports again cannot always be put on board ship at the moment of arrival alongside, as a vessel destined to call at many ports must have her cargo in systematic order, not only in the order of the ports, but also in relation to the character and weight of the articles exported. This means storage in transit sheds before loading, and the picking out, sorting and lifting, very often twice over, of the goods which have arrived. All these little points add to the necessity of eliminating hand labour, and doing by quick-acting machinery that which is necessary to hurry the vessel away to sea, and thus increase the number of voyages per annum.

Electric overhead travellers, such as are now used in the most modern railway transit sheds, with a longitudinal traverse of 450 ft. per minute, and both a cross traverse and lifting speed of 150 ft. per minute are probably the most suitable appliances for this work inside the sheds, while outside there should be a liberal supply of quick-acting jib cranes. At the most modern railway goods stations, where the same goods have ultimately to be handled, these quick-acting appliances, in combination with the modern electrically-propelled platform trucks, have been the cause of great economies.

In every case, apart from those where difficulties have been mentioned, cranes and other appliances should load direct from ship to lorry or railway wagon, and wagon to ship, though it is extraordinary to find how little provision has been made for this direct loading to transport vehicles at many of our large ports.

In the loading of coal for export very great changes ought to be made where old-fashioned plant and methods still exist. It is probable that coal shipment is more economically done on the north-east coast than elsewhere, largely by drop-bottom wagons; and there, at any rate, there is not the same great necessity for complete change of appliances as at other ports.

We ought to have a change in our wagons as well as in the tipping appliances, and a wagon carrying not less than 40 tons of coal should be provided for. Coal hoists and tips which could at first deal with the ordinary four-wheeled wagon containing 20 tons of coal could easily be designed in such a way as to be added to so as to enable the larger bogie wagon containing 40 tons of coal to be dealt with as these wagons are built, but in the meantime it is an obvious point that the use of 20-ton wagons for shipment coal would be better than the use of 10-ton wagons, as the saving in time and in the occupation of siding room is so great.

Millions of tons of coal are at present forwarded to the ports in 10-ton wagons, sometimes for export and sometimes for bunkering; but these small 10-ton wagons should be eliminated as rapidly as possible, and nothing less than a 20-ton vehicle, making a gross load of about 30 tons, put in their place, as a great national saving would result; the larger 40-ton wagons could follow as it became possible to construct them. Private wagon owners have done but little in enlarging wagon capacity and have only built about 2,600 20-ton wagons out of the estimated number of 700,000 owned, the majority of which are of 10-ton carrying-capacity, and probably 90 per cent. are used for carrying coal.

There is only one serious thing in the way of the more general adoption of 20-ton wagons for shipment coal, and that is, the small size of the tipping and coal-handling appliances at our ports, whether those ports are owned by public port authorities, or by railway companies. Many of them are quite up-to-date, and will lift the larger loads; but until any one port has all its coal and tipping appliances made up to the highest required capacity, those interested in the sale of shipment coal will not know whether the wagons they send will be put under the large or the small tipping appliances, and must continue to run the small 10-ton wagons. Taking 31 coal-exporting ports in Great Britain, there are only about 286 coal-tips which require alteration or reconstruction to lift a gross load of 30 tons, and for this comparatively small reason, that proportion of the 77,000,000 tons of coal which was rail-borne, and which was exported at ports other than five north-east coast ports in the year 1913, had nearly all to be carried in 10-ton trucks, representing a great waste of money which, if saved, would return a handsome interest on the cost of changing the tipping appliances, save the time of shipping, reduce the time of occupation of siding room, and give a quicker return of the wagons to the pits. No one is so much interested in saving siding rooms as a dock-owning company, as their space is small and the land extremely valuable. As an illustration of what could be done in saving space by using larger wagons, 1,000 net tons of coal carried in the ordinary 10-ton traders' wagons, which are only 7 ft. 6 in. wide, could be carried in wagons of the same length as the 20-ton wagon, but made 9 ft. wide with a saving in length over the whole train of 851 ft., or 41·8 per cent. The difficulty of arriving at the change in the form of wagon is due to their being no common ownership and no common interest which can influence the change.

No loss need be anticipated to wagon owners by such a change, as the 10-ton wagons would slowly die out, being retained meanwhile for land sale of coal, and, for reasons which need not be gone into here, they are at present suited to this class of trade.

Their replacement would be gradual, but if the life of a wagon be taken at twenty-five years, 28,000 wagons must be built each year to maintain the 700,000 private wagons, and the creation of 28,000 wagons a year of modern design would bring about a quick change in the economics of coal transport to our ports, for shipment.

The change in tipping appliances must precede the improvement in the wagon. If the wagons became railway-owned the figures would remain the same, but there would be the additional advantage that at those ports at which there were suitable imports the wagons could be used within certain limits for back loading.

The next important question affecting the economical operation of railways in this country under present conditions is the question of the ownership and the standardisation of wagon-stock, and in this matter engineering works are very much interested.

At the end of 1913, the railways of Great Britain owned 786,516 wagons, but in addition to this, it is estimated that private traders owned 700,000 wagons. The existence of this large number of private wagons is an anomaly, and a great source of unnecessary expense. Private ownership ought to be swept away by immediate legislation, and so long as the question is looked upon from a national point of view, the number of problems which such a change represents can be solved with very great benefit to the nation.

In wagon-stock there is a wide field for change when the time comes that goods platforms have to be altered, and doorways into goods sheds have been enlarged. At present, uniformity of outward form of the different classes required would only mean a reduction, instead of an increase, of dimensions of the body to the figures of the smallest capacity railway of the more important kind, leaving out small isolated lines, which are of no consequence.

Take as a round figure the total wagon-stock railway-owned and privately-owned to be 1,500,000, and accepting twenty-five years as the life of the wagon, then we require 60,000 wagons each year to replace those dying out. From this it may be suggested that if common ownership of all this rolling-stock enabled the maximum number of parts which wear out to be made to standard dimensions, really interchangeable, economies of manufacture would be introduced which, even with a small sum on each renewed wagon alone, without counting the much more important demands for daily repairs, would represent a very large annual sum.

In addition, if the tremendous labour and time involved in shunting out and sorting this vast array of traders' wagons which have each to be sent back empty to their own particular owners after each loaded journey can be got rid of by railway ownership, then without counting the cost of the return empty journey and without making any estimate of what the real cost of shunting out these traders' wagons comes to in a year, it is obvious that the trivial amount of one penny saved per day for one shunt per day for 300 working days on 700,000 wagons would amount to little short of a million sterling. It is quite sufficient, however, to show that the subject of change may be approached with the hope of a solid return.

Abolition of private ownership would also enable a most important improvement to be made by fitting all wagon-stock with continuous brakes. Unless such brakes are fitted we shall not reap all the advantages of longer and heavier trains as far too much time will be occupied in bringing these trains to a stand. It seems almost a contradiction to say that efficient continuous brakes will enable a train to make its throughout journey in less time, but it is essentially true.

There is nothing about the proposed change of ownership which need in any way lead to the confiscation of the capital involved in the present private ownership, as equitable adjustments could be made which would not only deal with those now interested in the earnings of the wagons, but also with that large body of firms and individuals who are interested in the construction and repair of railway rolling-stock. How great this latter interest is may be measured somewhat roughly by noting that as the repairs and renewals of railway-owned wagons work out at £4·61 per wagon per annum for Great Britain, the estimated number of 700,000 traders wagons would probably cost for the same work say, 3,227,000*l.* per annum. This figure will possibly be somewhat underestimated, but still it represents a very large interest, including as it should do the costs of materials, labour, all other charges, and profit, and would warrant the consideration of carefully thought-out plans for the construction of the best engineering works for the building and maintenance of this great number of wagons in various parts of the country, a problem rendered the more easy as the private repairing firms recently combined their forces.

The whole question of building and maintenance of wagons is one of the greatest importance, and it would appear as if the operation of large private works working parallel with the railway-owned works, was one of those things which ought not only to get the best results, but prevent a change of ownership of the wagons from operating in any way unfairly with the capital invested in the great industry of construction and repairs.

It is not generally known that the standardisation of traders' wagons was taken in hand by the railway companies in 1888 after certain accidents had happened. Meetings of the technical officers of the railways have taken place at the Railway Clearing House, and drawings and specifications have been produced, which have been developed or modified to suit modern requirements during the past thirty years. Of the 700,000 privately-owned or traders' wagons running on the British railways, it is known that 517,000 have been built to standard specifications. Such specifications have been prepared for 8-, 10-, 12-, 15- and 20-ton wagons of ordinary types, and for 10-, 15- and 20-ton tank wagons.

The general result has been to produce standard parts in very large numbers, the dimensions of which are based on those used by the railway companies themselves, though speaking broadly the traders' wagons are built for a small number of trades and can nearly all be alike, whereas the railway companies' wagons have to accommodate an immense variety of businesses demanding special consideration in each case.

Speaking in a very general way, the standardisation of parts of locomotives and carriages is a very small question compared with the importance of the standardisation of wagons in regard to their running parts and ironwork, as the numbers to be dealt with are so large.

We must, I think, look forward to hauling much longer and heavier goods and mineral trains, once our structure gauges are altered and our bridges are strengthened, and it may not be looking too far ahead to suggest that the use of wireless telephony is one of the things which is going to help in the operation of long goods or coal trains in the future.

The very successful use of wireless telephony by our Air Force—who are using an efficient and compact apparatus—points to the possibility of having a locomotive so fitted at the head of a train being put in easy communication with another locomotive at the end of the train, the drivers of both being thus able to work together, stopping or starting or applying the brakes on the instant of receiving a message which could also be communicated to the rear guard.

Our engineers have been justly proud of their permanent way, and have considered that the form used in this country, consisting of a wooden sleeper, cast-iron chairs, and a bull-headed rail gives the best results. The War has brought about such changes that one wonders whether the immense difficulties of obtaining sleepers from the Baltic ports, especially as the country in which they are grown is now controlled by enemy interests, will, in the future, cause any change to be made in the material used for our sleepers, and whether steel will in any large measure take the place of wood.

If the life of a steel sleeper is the same as that of a wooden one, the 300,000 tons of steel sleepers which would be required to replace the 4,500,000 wooden sleepers used each year by British railways would create a new steel manufacture for this country, using up our own pig-iron made from native ores, in the numerous new blast-furnaces which have been started in this country during the war, and saving the purchase of foreign-grown timber. It is true that our cast-iron chair does not lend itself readily to attachment to a metallic sleeper, and also that the earlier experiments with such sleepers were not altogether satisfactory, but since then a great development in the use of broken stone ballast, resulting in a well-drained road-bed, has eliminated the cinder ballast which was so destructive to steel, and it may yet be possible to consider whether the flanged or Vignoles rail of large section easily attached to a steel sleeper may not come into use if the whole question is looked at from the broad standpoint of endeavouring to help and foster our home industries.

Such a proposition would add to the work of our iron-ore miners, keep our blast-furnaces, going, find employment for rolling-mills, and continuous and steady work for some classes of labour after the war. There is no reason, if such sleepers could be accepted, why absolutely standard dimensions should not be agreed upon, and their use might be as extensive in England as it is on the Continent to-day.

So much is going to be done in the future by electrical operation that I am led to mention that it has been my lot to take a somewhat active part in certain phases of the Government Electric Power Supply Enquiry and to come into contact with many of those who are interested in the supply of cheap current for industrial use, and this has led to the conclusion that there is a very strong desire on the part of all who are likely to be large consumers to see that the views expressed by the Electric Power Supply Committee as to the creation of suitable super power stations is well-selected districts are carried out, though there are various objectors to the detail of the methods proposed. The leading idea is, however, one of co-operation in any well-devised scheme, and a recognition of the prospective advantages of at last having some central authority, possessing both knowledge and power, to deal with this great electrical question of power supply.

One of the most serious questions which any new body of electricity commissioners will have to decide is whether it is better to put your generating station in the midst of the coalfields or in the midst of the industries which you desire to supply with power. Is it cheaper to convey the coal for generation by a long line of railway, or to convey your current by a long line of copper? These will be nice questions involving the balancing of all-round costs and will vary much in different districts.

The railway demand for electric current will be far in excess of that for any other industry, and it is open to doubt whether it is wise to divorce the control of Generating Stations for railway supplies from the management of those who are responsible for the operation of the traffic, and the same question arises when some of the great municipal supplies for tramway working, as distinguished from lighting, are considered. The movement of traffic of all kinds requires the instant command of power, and knowledge of the requirements is not likely to be appreciated by those who have never come in contact with traffic problems. The super power station is a modern necessity, and the question of this control requires much discussion and thought.

There have been at least three Government Departments which have considered that they have interest

in connection with electrical matters, and their diversity of view has most frequently led to delay, and their decisions have often been guided by conservatism and, sometimes, want of knowledge.

Electrical progress is so rapid that it cannot prosper without a due recognition of the necessity for accepting changes of method, and the vigorous youth of the industry connected with it is such as to require the continuous assistance of broad-minded men whose one desire should be to assist in advancement.

It is not only in the manufacturing districts that electric current will be required, as we now see that its use is extending to agriculture, and it is stated that crops subjected to the new electrical treatment show most advantageous results. This being so, it may be that the distribution of current in agricultural areas will not only assist the farmer in working the light railways which I mention elsewhere, but the very fact of current being thus used will facilitate its distribution along roads in the country where, if he will, the farmer can make use of it for the stimulation of his cornfields.

Had it not been for the war, I believe a very great extension of the use of electric power would have taken place in railway-working, whereas no great additions to electrical plant—where they had not been initiated before the commencement of hostilities—have been possible during the last four years. The three chief additions to our electrical mileage which have been opened recently are those of the London and South-Western Railway for suburban traffic, the London and North-Western lines to Watford, and the Lancashire and Yorkshire Railway between Manchester, Bury, and Holcombe Brook. The voltage at the third rail is 600 for the two former, and 1,200 for the latter.

So far there does not appear to be any reason for supposing that when we can begin again to do work of this kind it will be rapidly extended for long lengths of main line of railway, but electrical working will remain for the present as a great stimulator of suburban traffic. It really is remarkable how, when each suburban line has been worked by electrical trains with great frequency and increased rapidity, there has been a very great growth of passenger traffic, and I cannot help thinking that the probable course of events will be that we shall find that electrification of the lines immediately round our great towns will quickly take place all over the country, and probably be added to in widening circles as time goes on; but it is not until these widening circles begin to touch one another, and thus enable longer-distance trains to run between one great centre and another, that we shall see electrical working used for long-distance passenger-trains. The additional revenue required to pay interest on the large capital outlay can be made most rapidly from the suburban traffic in well-selected districts and then the extension of main-line work can be carried out without an outlay which taken by itself might be unremunerative.

For shunting and operating in and about large towns where there are already electrical railways for suburban traffic, there seems to be an immediate future, and we shall possibly see the application of such methods to heavy goods-trains at a later date.

When expressing the hope of seeing great progress in the future for electric traction, I would again, as I have done on several occasion in this room, venture to suggest that there is much to be gained by regenerative control on electric railways. The difficulties of obtaining it in all forms of electric traction are known, but let us hope they may be swept away. It seems a barbarous thing to continue to convert power at every stop into heat by the abrasion of the tyre and the brake block instead of turning the stored-up energy of the train into useful work by the generation of current.

The very successful operations in America which were detailed to us by Mr. Hobart in his "James Forrest" Lecture are an indication of what can be done in hauling heavy trains by electric locomotives. It may be necessary to mention one or two cases where our American friends have produced extremely powerful electric locomotives to show the way in which they are seeking for more efficient haulage. For instance, a very powerful electric passenger locomotive for the Chicago, Milwaukee and St. Paul Railway has been produced of 3,200 h.p., with a tractive effort of 112,000 lbs., measuring 90 ft. overall, weighing 266 tons, and having an adhesive weight of 330,000 lbs.

For freight services the Pennsylvania Railroad has built an electric locomotive weighing 240 tons, of which 198 tons is on the 12 driving wheels. It has a starting tractive effort of 130,000 lbs., and it is fitted with regenerative control. In this case two locomotives are used, one at the head and the other at the tail of the train. When operating with two locomotives it is intended to haul loads of 6,300 tons on a ruling grade of 1·33 per cent.

It is hardly likely that any system of unification of main-line railways will lead to any large additions to their mileage after the war, but that junctions and connections will be put in here and there is probable to enable cross-country services to be started. There is however another field which will call for much engineering skill and commercial forethought in connection with agricultural lines. If this country is to become a much greater food-producing centre than it has been in the past, ample facilities for transport will be required by the farming population for their products, and curiously enough the war has created the possibility of finding materials for agricultural light railways of a very suitable character, and finding them at once on the conclusion of peace.

There are many hundreds of miles of 60 centimetre gauge railways, which have been laid by the British in France, together with thousands of trucks and locomotives. When these are brought home they might well be used for a well-thought-out scheme of agricultural lines. When this becomes possible a suitable committee of engineers and road surveyors, in combination with the Board of Agriculture, could decide where and how they should be laid to be of the greatest use to the nation. They should not in any way be hampered by existing light railway or tramway legislation, but should be constructed under new rules which should be formulated to enable them to be built in the most economical way, and thus avoid having their first cost overweighted with unnecessary requirements. It would seem that such a proposal would find a good deal of new work, involving the consideration of many new points.

We shall have to brace ourselves to meet another great competition in the carrying trade owing to the wonderful increase in the shipbuilding capacity of the United States. Mr. Edward N. Hurley, of the United States Shipping Board, has stated that their shipbuilding programme will give them by the end of 1920, 25,000,000 tons of shipping, and whatever we may gain by the destruction of the ships of our enemies we shall find more than counterbalanced by the active business capacity of our friends, as Mr. Hurley is surely right when he says that their great war effort will "make them a great maritime nation."

There has been no greater example during the war of concentrated engineering effort than the construction of the Hog Island Shipbuilding Yard in America. Hog Island was a swamp in October, 1917, when work was started on the 900 acres. The owners have contracted to turn out 120 ships in 22 months, dating from September, 1917, the date of the first contract. There are 10 yards of five berths each, each set of five having a complete organisation subject to a central control, which employs a staff of 30,000 men with the most complete up-to-date equipment, and every kind of organisation for housing, feeding, and looking after the welfare of the whole staff.

This is but one of the American yards, and with such facilities and boundless energy, we can hardly expect that after the war these great centres will not become most active competitors with our own shipbuilders.

In our competition with the rest of the world we must always remember that we have to take into account the natural advantages as well as the accumulated experience of other countries. Those countries which are rich in water-power have opportunities of creating current at low prices and transmitting it to long distances. America is but one of the countries which is so happily furnished, and we are even now told that Norway is exporting current by cable to Denmark from generating stations run by the wealth of water in her many waterfalls.

In addition to this our friends in the United States have the benefit of cheap coal. The Coal Conservation Committee (Ministry of Reconstruction) in their Final Report* show that the output of coal per man employed above and below ground at United States collieries in 1913 was 681 tons, as compared with 259 tons per head in Great Britain.

Whether this is due to the coal being easier to get, or to the great use of machinery, or to greater exertion per man, or less restriction of hours, or to a combination of all these points, the fact remains that it has been possible for the American railways to purchase locomotive coal at the pit's mouth, during a number of years before the war, in the United States at about one-half the price at which coal could be purchased for the same purpose in this country.

All these prospects of keen competition are but additional reasons for continuing the search for new methods of reducing costs of transportation per ton-mile, whether by water or by rail, and if we are to be successful in the economical production of our engineering output and are to continue to exchange our machinery for the commodities which we require from the rest of the world for our manufactures, no trouble will be too great, and no forethought thrown away which will enable us to maintain our National position.

ELECTRIC WELDING AS APPLIED TO STEEL SHIP CONSTRUCTION.

Introduction.

By H. A. Hornor, Member.

In March of this year the Emergency Fleet Corporation† appointed a special committee to investigate and advise the corporation on the status of the art of electric welding and its possible employment in hastening the completion of the steel ship programme. Professor Comfort A. Adams was selected as chairman of this committee, not only because of his long study of the subject, but also on account of his energy in organising a similar committee as a sub-committee of the Research Committee of the American Institute of Electrical Engineers. This original committee had already gathered a great deal of important data and had arranged with the United States Shipping Board for the visits of Captain Caldwell to this country for the purpose of explaining the methods and extent of the application in Great Britain.

One of the earliest suggestions of the Electric Welding Committee was the necessity for trained operators, and the Emergency Fleet Corporation, acting upon this suggestion, added a branch for the study of this subject to the Education and Training Section. The main purpose of this work is to provide skilled men to the shipbuilders, not only for the performance of good welding, but to act as instructors for other workmen.

It was early recognised that the operator, although most important in the actual making of a good weld, required something far more important back of him in the accomplishment of perfect joints in the steel structure of a vessel. No man on the Welding Committee to-day fails to realise that the joining of the essential parts of a ship is a vital and serious question. On the other hand, no member of the committee doubts that, if these joints are designed after careful study by the naval architect, the engineer, and technician, the application can be made most successfully with a resultant of increased speed of construction. With this in mind, the Fleet Corporation desired to discuss all the questions connected with this subject with the technicians of the shipbuilding industry in order that no detail, no matter how minute, should escape complete investigation before this industry broadened its field of action. Therefore, a programme was prepared to cover in general the entire subject and to encourage a full consideration of the details involved.

A cursory glance at this programme will show that the fundamentals of the art had not been grouped in any specific order, and that no symbols had been adopted so that drawings of a comprehensive nature could be prepared. The first discussion consists of an explanation of the proper nomenclature and symbols that have now been approved as standard by the Electric Welding Committee. The language, having once been introduced, the investigator turns naturally to the tools which are now available for performing the work. This forms the subject of the second discussion. With these two important factors, the third discussion naturally turns to the advantages that may be gained in their use in the construction of the steel ship. This latter subject applies both to the present riveted ship and the future ship that may be more largely welded, a subject discussed in the fourth and fifth meetings. The sixth discussion makes a summary of all the preceding ones and emphasises the essential points dealing with the successful application of electric welding in steel ship construction.

Nomenclature for Electric Welding*.

By Naval Constructor H. G. Knox, U.S.N.

It is evident to all persons interested in the nomenclature of welding that, if we are to avoid confusion and retarded progress, we must all talk the same language in discussing the same thing. A typical example of the result where the design followed the actual working conditions is found in the city of Brooklyn, New York, where, I understand, Fulton-street was laid out along an old cow path leading up from the ferry. As a consequence of this system of lay-out, it is very confusing to get about that city. The city of Washington, on the contrary, was laid out after considerable scientific study and based on the competitive designs of architects. In this case, the development followed after the design and the result is very much more satisfactory. As a further illustration, you are reminded that the actual working steam engine was in use years before anybody dreamed of thermodynamics, while electricity, following its discovery by Benjamin Franklin, was entirely a laboratory product until the standardisation in nomenclature and the theory of the subject had been pretty well worked out. As a result, electricity is a most satisfactory science to work in because all the terms are clear and concise, and I think we owe a great debt to the electrical engineers for their remarkable work in the standardisation of their rules.

Standard Symbols.—It is also necessary in welding that at the outset we adopt a uniform terminology. It was early suggested at one of the meetings of the Welding Committee that we divide all types of welded joints into several main classes, and that a mnemonic symbolism for each be adopted. First, under this classification would come the type of joint, such as the butt, the jog, the lap, the Tee and the strap. The mnemonic symbol proposed was for the butt joint the symbol B, the jog, J, the lap, L, the Tee, T, and for the strap, S.

Next in point of continuity of the complete mnemonic system of symbols are the various types of weld. First, come the foundation or base weld, which is the first run put at the bottom of a heavy V, next, the bolt weld, then the edge weld, the fill weld, the plug weld, the seam weld, the tack weld, and the special types of weld. To illustrate: a joint called a lap filled double tack would, under the mnemonic system, be represented by the symbol L F K K. Since such a notation would be a great deal of bother for the draughtsman, we have formed other classifications, and the mnemonic system was abandoned in favour of a more nearly symbolic notation, in which certain symbols, and in some cases numbers have been used, with the result that the designations are more easily placed on the drawings.

Fig. 1 shows the first page of the instruction chart illustrating the finally-adopted symbols. In the first group are the points which should be covered by the general specifications. The second group shows the design, the position of the weld and the type, and this the draughtsman must use. There is here a slight similarity in the use of terms that later may be modified for the sake of clearness. Group three will be embodied later in a handbook for the shop, and will cover the material and size of the electrodes, the current and other necessary information for the guidance of the operator.

* (Cd. 9084) 1918, p. 61.

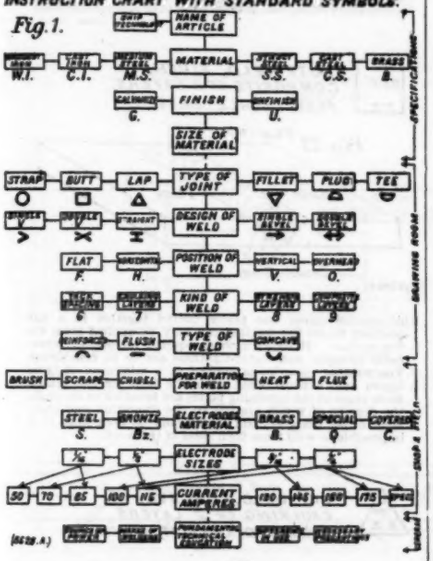
† The executives of the Education and Training Section of the Emergency Fleet Corporation at the present time are as follows: Director, Mr. Louis E. Reber; Superintendent of Training, Mr. E. E. MacNary; Head of Electric Welding Branch, Mr. H. A. Hornor. We reproduce this article from the Journal of the *Engineers' Club of Philadelphia*.

* Paper read before the Engineers' Club of Philadelphia, June 26, 1918.

Type of Joint.—Figs. 2 and 3 represent one of the design subdivisions, namely, the type of joint. These joints are all familiar to shipbuilders. Three characteristic types of the strap joint are shown in Fig. 2; on the left is an ordinary strap joint in which the joint is backed up by an angle; in the centre, an ordinary strap; and on the right, a joggled strap. All strap joints are symbolised by the circle. All the other symbols which go to tell the complete story of the weld are placed inside that circle, as will be explained later. Next is the butt joint (Fig. 4), and is denoted by the square. On the upper right is a type of joint, which, in the original nomenclature, was called a flanged butt. Then is the lap joint (Fig. 3), denoted by the triangle, with the apex up, and under this type is shown the plain lap, the joggled lap and the flanged lap. Of the three other types of joints, the first (Fig. 5) is the fillet joint; the second, the plug joint (Fig. 6), and the third (Fig. 7), the Tee joint. The fillet joint is rather hard to define other than by reference to these sketches, but it is the weld that is made around fittings to plates and its use will be clear whenever the occasion arises. It is denoted with a triangle with the apex down. The

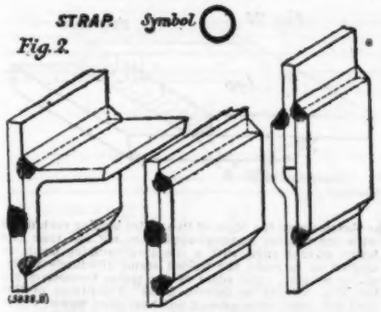
INSTRUCTION CHART WITH STANDARD SYMBOLS.

Fig.1.



STRAP. Symbol ○

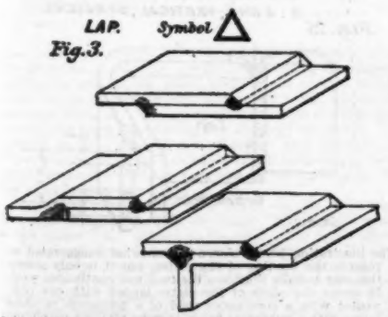
Fig.2.



Strap weld is one in which the seam of two adjoining plates or surfaces is reinforced by any form or shape to add strength and stability to the joint or plate. In this form of weld the seam can only be welded from the side of the work opposite the reinforcement, and the reinforcement of whatever shape must be welded from the side of the work to which the reinforcement is applied.

LAP. Symbol △

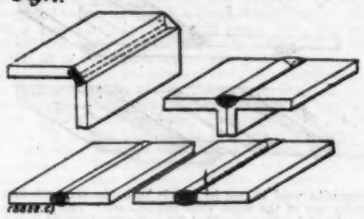
Fig.3.



Lap weld is one in which the edges of two plates are set one above the other and the welding material so applied as to bind the edge of one plate to the face of the other plate. In this form of weld the seam or lap forms a raised surface along its entire extent.

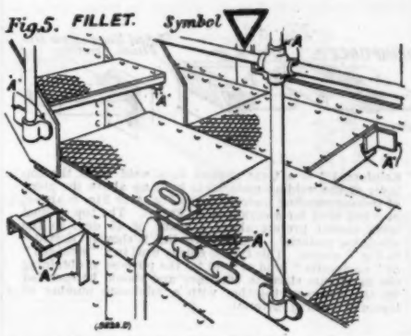
BUTT. Symbol □

Fig.4.



Butt weld is one in which two end plates or surfaces are brought together edge to edge and welded along the seam thus formed. The two plates when so welded form a perfectly flat plane in themselves, excluding the possible projective caused by other individual objects, as frame, straps, stiffeners, &c., or the building up of the weld proper.

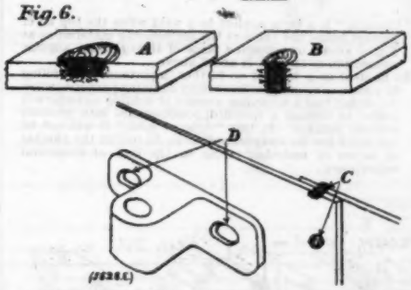
Fig.5. FILLET. Symbol ▽



Fillet weld is one in which some fixture or member is welded to the face of a plate by welding along the vertical edge of the fixture or member (see "welds" shown and marked "A" on illustration at left). The welding material is applied in the corner thus formed and finished at an angle of 45 deg. to the plate.

PLUG. Symbol ⌓

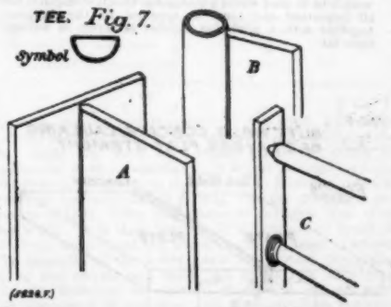
Fig.6.



Plug weld is one used to connect the metals by welding through a hole in either one plate (Fig. A) or both plates (Fig. B). Also used for filling through a bolt hole as at Fig. C, or for added strength when fastening fixtures to the face of a plate by drilling a countersunk hole through the fixture (Fig. D) and applying the welding material through this hole, as at Fig. D, thereby fastening the fixture to the plate at this point.

TEE. Fig. 7.

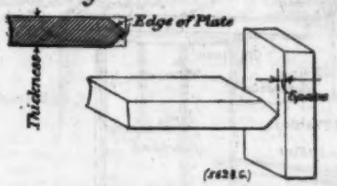
Symbol ⊤



Tee weld is one where one plate is welded vertically to another, as in the case of the edge of a transverse bulkhead (Fig. A) being welded against the shell plating or deck. This is a weld which in all cases requires exceptional care and can only be used where it is possible to work from both sides of the vertical plate. Also used for welding a rod in a vertical position to a flat surface, as the rung of a ladder (Fig. C), or a plate welded vertically to a pipe stanchion (Fig. B), as in the case of water-closet stalls.

SINGLE 'V' Symbol Space for any Thickness

Fig.8.



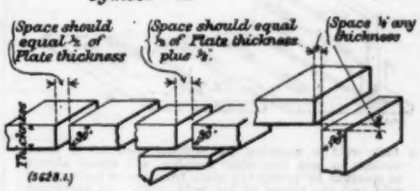
Single "V" is a term applied to the "edge finish" of a plate when this edge is bevelled from both sides of an angle, the degrees of which are left to the designer. To be used when the "V" side of the plate is to be a maximum "strength" weld, with the plate setting vertically to the face of an adjoining member, and only when the electrode can be applied from both sides of the work.

DOUBLE 'V' Symbol Space for any Thickness

Fig.9.

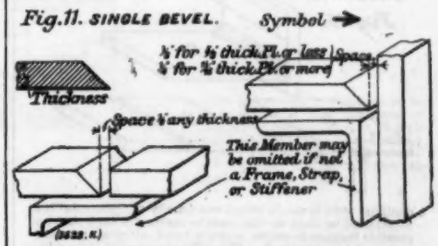
Double "V" is a term applied to the "edge finish" of two adjoining plates when the adjoining edges of both plates are bevelled from both sides of an angle, the degrees of which are left to the designer. To be used when the two plates are to be "butted" together along these two sides for a maximum "strength" weld. Only to be used when welding can be performed from both sides of the plate.

Fig.10. STRAIGHT. Symbol =



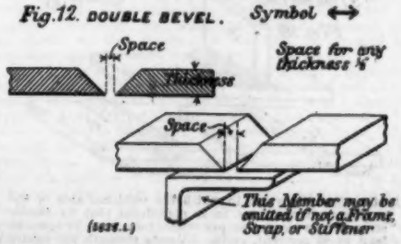
Straight is a term applied to the "edge finish" of a plate, when this edge is left in its crude or sheared state. To be used only where maximum strength is not essential, or unless used in connection with strap, stiffener or frame, or where it is impossible to otherwise finish the edge. Also to be used for a "strength" weld when edges of two plates set vertically to each other—as the edge of a box.

Fig.11. SINGLE BEVEL. Symbol →


⅛" for ¼" thick Plate or less
¼" for ⅜" thick Plate or more
Space
Thickness
Space ¼ any thickness
This Member may be omitted if not a Frame, Strap, or Stiffener

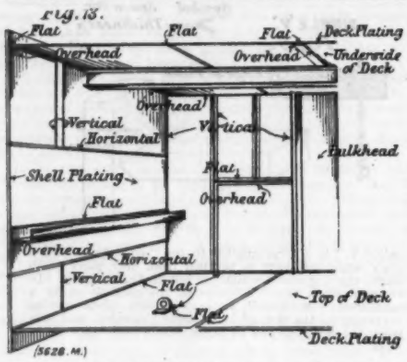
Single bevel is a term applied to the edge finish of a plate when this edge is bevelled from one side only to an angle, the degrees of which are left to the designer. To be used for "strength" welding when the electrode can be applied from one side of the plate only, or where it is impossible to finish the adjoining welding surface.

Fig.12. DOUBLE BEVEL. Symbol ↔



Double bevel is a term applied to the edge finish of two adjoining plates when the adjoining edges of both plates are bevelled from one side only to an angle, the degrees of which are left to the designer. To be used where maximum strength is required, and where electrode can be applied from one side of the work only.

Fig. 13.



Flat position is determined when the welding material is applied to a surface on the same plane as the deck, allowing the electrode to be held in an upright or vertical position. The welding surface may be entirely on a plane with the deck, or one side may be vertical to the deck and welded to an adjoining member that is on a plane with the deck.

Horizontal position is determined when the welding material is applied to a seam or opening the plane of which is vertical to the deck and the line of weld is parallel with the deck, allowing the electrode to be held in an inboard or outboard position.

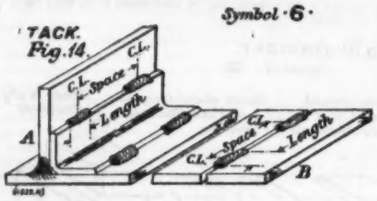
Vertical position is determined when the welding material is applied to a surface or seam whose line extends in a direction from one deck to the deck above, regardless of whether the adjoining members are on a single plane or at an angle to each other. In this position of weld the electrode would also be held in a partially horizontal position to the work.

Overhead position is determined when the welding material is applied from the under side of any member whose plane is parallel to the deck and necessitates the electrode being held in a downright or inverted position.

Symbol 6.

TACK.

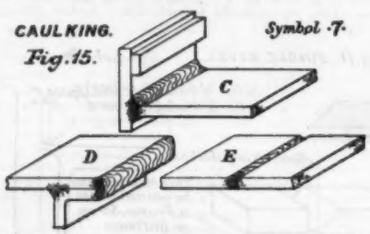
Fig. 14.



A tack weld is applying the welding material in small sections to hold two edges together, and should always be specified by giving the space from centre to centre of weld and the length of the weld itself. No particular "design of weld" is necessary of consideration. A tack is also used for temporarily holding material in place that is to be solidly welded, until the proper alignment and position are obtained, and in this case, neither the length, space, nor design of weld is to be specified.

CAULKING. Symbol 7.

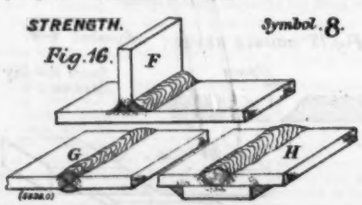
Fig. 15.



A caulking weld is one in which the density of the crystalline metal used to close up the seam or opening is such that no possible leakage is visible under a water, oil or air pressure of 25 lb. per square inch. The ultimate strength of a caulking weld is not of material importance; neither is the "design of weld" of this kind necessary of consideration. The operator must be the judge in the number of layers needed for a tight weld, although the designer should specify a minimum amount of layers.

STRENGTH. Symbol 8.

Fig. 16.

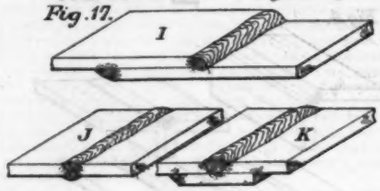


A strength weld is one in which the sectional area of the welding material must be so considered that its tensile strength and elongation per square inch must be equal at least to 80 per cent. of the ultimate strength per square inch of the surrounding material. (To be determined and specified by the designer.) The welding material can be applied in any number of layers beyond a minimum specified by the designer.

The density of the crystalline metals is not of vital importance. In this form of weld, the "design of weld" must be specified by the designer and followed by the operator.

COMPOSITE. Symbol 9.

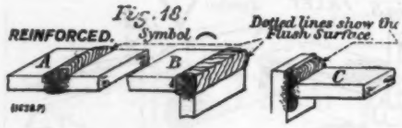
Fig. 17.



A composite weld is one in which both the strength and density are of the most vital importance. The strength must be at least as specified for a "strength weld," and the density must meet the requirements of a "caulking weld" both as above defined. The minimum number of layers of welding material must always be specified by the designer, but the welder must be in a position to know if this number must be increased according to the welder's working conditions.

Fig. 18.

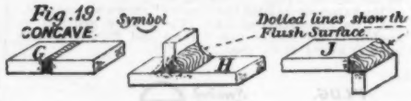
REINFORCED. Symbol ⌒ Dotted lines show the Flush Surface.



"Reinforced" is a term applied to a weld when the top layer of the welding material is built up above the plane of the surrounding material as at Fig. A or Fig. B above, or when used for a corner as in Fig. C. The top of final layer should project above a plane of 45 deg. to the adjoining material. This 45-deg. line is shown "dotted" in Fig. C above. This type is chiefly used in a "strength" or "composite" kind of weld for the purpose of obtaining the maximum strength efficiency and should be specified by the designer, together with a minimum number of layers of welding material.

Fig. 19.

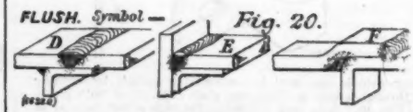
CONCAVE. Symbol Dotted lines show the Flush Surface.



"Concave" is a term applied to a weld when the top layer finishes below the plane of the surrounding material as at Fig. G above, or beneath a plane of 45 deg. at an angular connection as at Figs. H and J above.

To be used as a weld of no further importance than filling in a seam or opening, or for strictly caulking purposes, when it is found that a minimum amount of welding material will suffice to sustain a specified pound-square inch pressure without leakage. In this "type of weld" it will not be necessary for the designer ordinarily to specify the number of layers of material, owing to the lack of structural importance.

FLUSH. Symbol — Fig. 20.

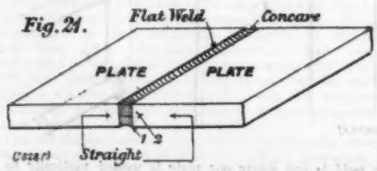


"Flush" is a term applied to a weld when the top layer is finished perfectly flat or on the same plane as on the adjoining material as shown at Figs. D and E above, or at an angle of 45 deg. when used to connect two surfaces at an angle to each other as at Fig. F. above. This type of weld is to be used where a maximum tensile strength is not all important and must be specified by the designer, together with a minimum number of layers of welding material.

72 F I

BUTT WELD, CONCAVE, CAULKING OF 2 LAYERS, FLAT, STRAIGHT.

Fig. 21.

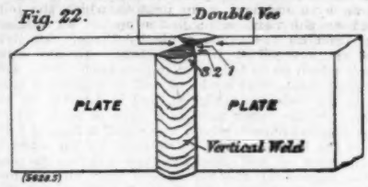


The symbol shown represents a butt weld between two plates with the welding material finished concaved and applied in a minimum of two layers to take the place of caulking. The edges of the plates are left in a natural shear cut finish. This symbol will be quite frequently used for deck plating or any other place where strength is not essential, but where the material must be water, air or oiltight.

83 V X

BUTT WELD, REINFORCED, STRENGTH OF 3 LAYERS, VERTICAL, DOUBLE VEE.

Fig. 22.

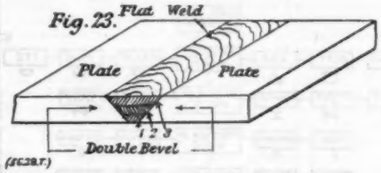


This symbol is used where the edges of two plates are vertically butted together and welded as a strength member. The edges of the adjoining plates are finished with a double "V" and the minimum of three layers of welding material applied from each side, finished with a convex surface, thereby making the sectional area per square inch of the weld greater than that of the plates. This will be a conventional symbol for shell plating or any other members requiring a maximum tensile strength, where the welding can be done from both sides of the work.

33 F

BUTT WELD, FLUSH, COMPOSITE OF 3 LAYERS, FLAT, DOUBLE BEVEL.

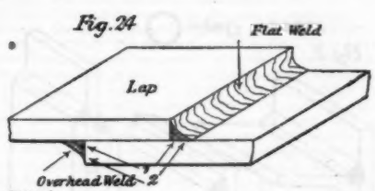
Fig. 23.



This symbol shows two plates butted together in a flat position where the welding can only be applied from the top surface. It shows a weld required for plating where both strength and water-tightness are to be considered. The welding material is applied in a minimum of three layers and finished flush with the level of the plates. Both edges of the adjoining plates are bevelled to an angle, the degrees of which are left to the discretion and judgment of the designer, and should only be used when it is impossible to weld from both sides of the work.

LAP WELD, CONCAVE, CAULKING OF 2 LAYERS OVERHEAD AND FLAT, STRAIGHT.

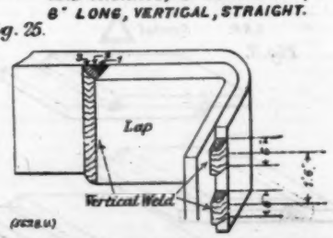
Fig. 24.



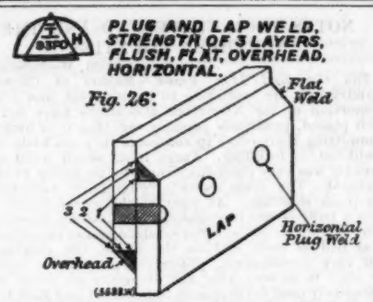
The sketch shows the edges of two plates lapping each other with the welding material applied in not less than two layers at each edge, with a concaved caulking finish, so applied as to make the welded seams absolutely water, air or oiltight. The edges of the plates themselves are left in a natural or sheared finish. Conditions of this kind will often occur around bulkhead door frames where maximum strength is not absolutely essential.

LAP WELD, REINFORCED, STRENGTH OF 3 LAYERS AND TACKING, 18" CEN. TO CEN, 6" LONG, VERTICAL, STRAIGHT.

Fig. 25.



The illustration herein shown is somewhat exaggerated as regards the bending of the plates, but it is only shown this way to fully illustrate the tack and continuous weld. It shows the edges of the plates lapped with one edge welded with a continuous weld of a minimum of three layers with a reinforced finish, thereby giving a maximum tensile strength to the weld, and the other edge of the plate, tack welded. The tacks are 6 in. long with a space of 12 in. between the welds or 18 in. from centre to centre of welds. In both cases, the edges of plates are left in a natural or sheared state.



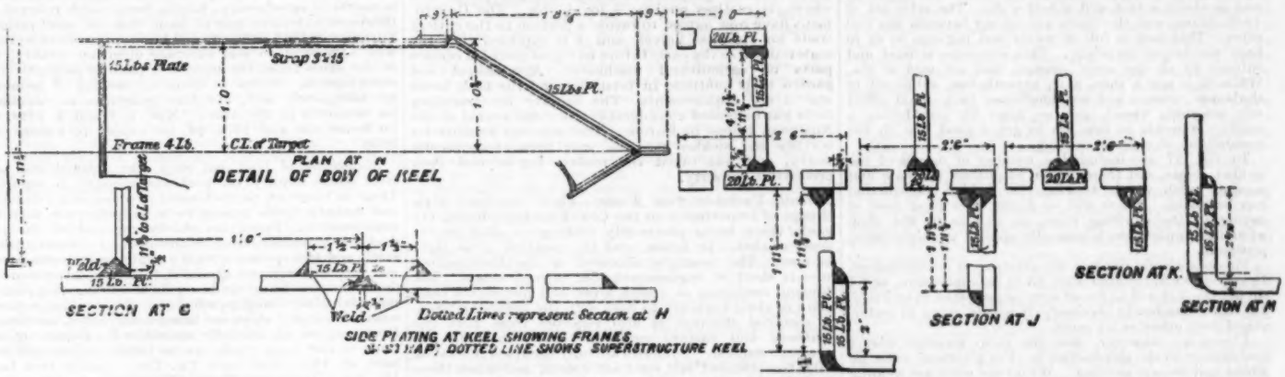
The sketch shows a condition exaggerated, which is apt to occur in side plating where the plates were held in position with bolts for the purpose of alignment before being welded. The edges are to be welded with a minimum of three layers of welding material for a strength weld and finished flush, and after the bolts are removed, the holes thus left are to be filled in with welding material in a manner prescribed for strength welding. The edges of the plates are to be left in a natural or sheared state, which is customary in most cases of lapped welding.

thereby reducing the electrode material. The straight weld, Fig. 10, with the symbol of a modified "I," or "H" placed on its side, is used only for light plates, because the arc is unable to get down between thicker plates and make a good weld at the bottom. If it were attempted to use the arc in a deep, straight-sided opening with a bare electrode, it would jump from side to side and off the body of the electrode rather than off the point. It is necessary, where this joint is used, to vary the space between the edges of the plate, depending upon the thickness of the plate. The single bevel is in some ways an unusual joint, not as common as the double bevel, but it has its uses, particularly in horizontal seams. It is also claimed to be more economical from the machining point of view, because only one plate edge is machined. The double bevel joint is probably the one that will be most employed in ship construction. The symbols for the single and double bevel are the single and double arrow.

Position of Weld.—In arc welding the position of the weld makes a great difference. Fig. 13 shows the four different positions, namely, flat, horizontal, vertical and overhead. The flat is the most usual and probably the most favourable position, as though it were being done on a table. The horizontal is such a seam as would be made on a wall along the top of the wainscoting. The vertical, of course, is obvious, as is also the overhead. As to the speed of welding, there is not much difference between the flat and the vertical, and when the welders become skilled there is not much choice, because they can make the two with equal rapidity. When the horizontal weld is considered, it would probably go only 90 per cent. as fast as on the flat weld. The quality of the welds is probably about equal. On the overhead weld the speed falls, being only about 60 per cent. that of the flat weld. It is slow because it is difficult to make the arc work uphill, and the strain on the operator is greater. The strength of the welds made in different positions is up to the welder and there can be no rule set. Some experts, however, say that if the flat is 100 per cent., the vertical is 90 per cent., the horizontal 85 per cent., and the overhead 80 per cent., but that is based on the margin of safety rather than the actual fact, and the research committee, at least, is not yet to the point of stating that any difference in the quality of the weld is due to its position.

Kind of Weld.—The next thing the designer has to tell the welder is the kind of weld to make. The tack weld, shown in Fig. 6, is represented by the symbol 6, and is used where neither strength nor tightness is needed. In specifying a tack weld it is necessary to give the length of each tack and the distance from centre to centre, so that the man on the job may know what the designer contemplated in the way of strength. The next is a caulking weld, symbol 7, in which the prime requisite is not strength, but requisite density to assure water or oil tightness. I have great respect for the man who drew these figures, because on paper there is very little difference in them. Symbol 8 is a strength weld, and as a matter of fact, a good strength weld will be also usually a good caulking weld. For completion, however, there is specified a composite weld, which has for its symbol the figure 9. This weld has both qualities of the strength and caulking welds. It embodies the strength of the former and the density of the latter.

Type of Weld.—The next subdivision is here called the "type of weld," but that name may be changed, for the sake of simplifying the terminology. The suggestion at least, has been made to change it to "finish of weld." The first "type of weld" is the reinforced weld, as is very clearly shown in Figs. 18, 19, and 20 in three different types. In the flush type the metal is finished straight across, as in the case of a flush rivet. The concave weld shows the surface does not need to be filled up full, as in the case of these three illustrations. Being so closely related to strength, the finish of the weld will ultimately



SIDE PLATING AT KEEL SHOWING FRAMES, &c. (1) KEEL PLATE; DOTTED LINE SHOWS SUPERSTRUCTURE KEEL

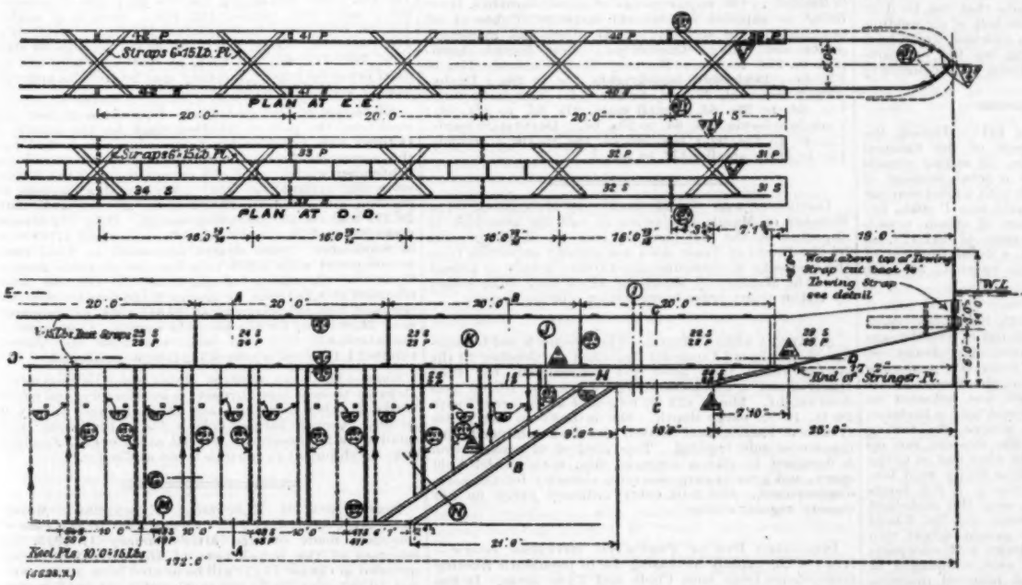

Straps 6-15 Lb. Pl.
PLAN AT C.E.
Straps 6-15 Lb. Pl.
PLAN AT O.O.
Wood above top of Towing Strap cut back to
Towing Strap see detail
W.L.
End of Stringer Pl.
Keel Pls 10.0-15 Lbs

FIG. 27.

General Notes.—All butt straps to be of 15 ± plating, 3 in. wide, and to be applied on inboard side of plating. All butt straps to be fastened to the forward plate in the shops. All symbols bearing a small ● represent shop work.

plug joint is the weld used where it is necessary to join one plate to another by means of punching or otherwise making a hole in one plate, such as for service bolts or other forms of preliminary bolting up work, which later requires filling in. It also applies to welds through holes in forgings used in securing the forgings to plates. The symbol in this case is a half-circle and straight line convex side up. The Tee joint, which is shown in two or three typical forms, is denoted by a half-circle with the convex side down.

Design of Weld.—We now come to the weld itself. The first design, Fig. 8, is the single "V," and its symbol is the letter "V" placed on its side. The application of the V is obvious. As a matter of fact, the V-joint is very largely confined to heavy plates where they are accessible on both sides and is closely related to the bevel design below. The double "V," Fig. 9, is used in joining plates or forgings, and is applied in the case of joints in heavy plates where the plates are accessible from both sides. In very heavy plates a successful type of joint may be made by using small triangular filler pieces, have to be specified by the drafting room. To-day the designer asks the welder how to best do a job, but of course, ultimately, the design properly symbolised will be shown on the drawing or else will be covered by standard specifications.

Fig. 21 shows the combination of symbols. The square is the symbol of the butt joint. The inverted half-moon inside the square at the top shows that it is a concave type of weld. Underneath this the first numeral "7" shows that it is a caulking weld, the next numeral "2" behind the "7" shows that the operator must put in two layers. The letter "F" on the same line shows that the position of the weld is flat and the "I" in the bottom of the square indicates that the design of the weld is straight. In the next diagram (Fig. 22) the symbols may be read off in the same way as above illustrated. In the third diagram on Fig. 23 the square symbol indicates the butt weld, the dash in the top of the square shows that it is flush, the numeral "9" shows that it is composite, numeral "3" determines the number of layers, the letter "F" makes it a flat weld and at the

bottom the dash with the arrow heads on each end designates it as a double bevel design.

Fig. 24 illustrates some additional symbols showing a caulking weld of two layers. It is shown both overhead and flat and the plate finish is straight. The second diagram in Fig. 25 is more complicated, and is of a lap weld, reinforced with three layers after tacking. The distance of the tacking from centre to centre and length of the tacks and the finish are all given. The third diagram in Fig. 26 is another application of the same thing, in which two kinds of joints appear, the symbols being superimposed, indicating that it is a plug and lap joint. Many combinations of symbols have been worked out and are very interesting, as is also the ease with which they may be placed on the drawing.

Design of Battle-Towing Target.—Fig. 27 shows a portion of the steel keel for a battle-towing target now building at the Norfolk Navy Yard. The design was prepared for me by the Sub-Committee of Design of the Electric Welding Committee, and shows the method of building the steel keel with electrically-welded joints. It also demonstrates the ease of applying the symbols which I have just explained, and I wish to call attention to the lack of the usual dimensioning that would be necessary on a similar riveted structure. The upper structure is of wood. The buoyancy is all in the wood so that if the target is shot to pieces the structure will still float. The wood is fitted to the shelf and built up to quite a height. The keel goes down some 15 ft. and is about a foot and a half wide. The sides are of 15-lb. plates and the floors are set up between the two sides. This keel is full of water and pig-iron so as to hold the target vertically. This structure is rigid and subject to all the wave stresses that are met at sea. While it is not a ship, it is, nevertheless, subjected to the same stresses and sea conditions that would affect any sea-going vessel, and we hope by introducing a variety of welds in this job to get a good line on the possibilities of electric welding.

In Fig. 27 are included a number of details of the welded joints, and there again emphasise the ease and rapidity with which drawings for welded construction can be made. There will no doubt be a great deal of saving in the drafting room, as well as in the shop when this application is generally applied to shipbuilding processes.

This practically finishes the question of nomenclature. It is not so complicated after all in its conception, and I do not think it will be found very complicated in practice. Its use is absolutely necessary, if we are going to understand each other as we must.

I consider, however, that the main message that I can deliver to the shipbuilder is—For goodness' sake, go ahead and use arc welding. We do not want arc welding of the whole ship yet, nor do we want to do extensive jobs, but there are thousands of jobs that can be done profitably, in money and time, by the help of arc welding, and by the help of the classification societies, which have already done so much in opening up the extensive field of this very remarkable addition to the industry of shipbuilding.

Falkland Islands Shipping in 1917.—During the year 1917, according to the report of the Colonial Secretary of the Falkland Islands, 12 sailing vessels were entered in the Colony, with a total tonnage of 16,005, as compared with 21 in 1916, with a total tonnage of 26,361. Only one of these vessels was British, her tonnage being 2,324. The number of steam vessels entered was 59, with a total tonnage of 117,127, as compared with 103 in 1916, with a total tonnage of 227,193. Of the above 59 vessels entered, 32 were British, with a tonnage of 89,984.

Interesting Salvage Work.—An interesting piece of salvage work has just been completed by the Salvage Section of the Admiralty. The steamship Araby, of about 3,300 tons register, bound from the Argentine with a cargo of oats, ran aground on the French Coast on December 21, 1916. The vessel was refloated on December 23, and whilst being assisted into a harbour, then very busily engaged on war service, the towing hawsers parted. The forepart of the steamer ran up on to one of the harbour piers and the after end on to the other pier, causing the ship to become firmly fixed fore and aft athwart the harbour entrance. A few hours later the steamer broke her back near the stokehold bulkhead. The stokehold, engine-room and No. 2 hold filled rapidly, and the water also gained access into Nos. 3 and 4 holds. The vessel's decks, with exception of the poop and forecastle decks, were submerged at high water. In view of the great national interests involved, salvage operations were commenced immediately, the wreck being subsequently lifted partially by camels and partially by pumping and taken in harbour. The Araby, broken in two, was held together only by a few deck plates, &c. These plates were cut apart by oxy-acetylene gas, and the two halves filling they settled down on an even keel. By January 18, 1917, both halves were refloated and beached inside of the harbour clear of all traffic. Pending opportunity to remove the two portions of the wreck, they were allowed to lie in this position until this summer, when the space occupied being urgently required by the military authorities, steps were taken to remove them. In the meantime the two halves of the vessel had been made watertight by the erection of concrete bulkheads at the after end of the fore half and the fore end of the after hold. In July the two halves were prepared for sea. By August 15 both halves were refloated and were towed across the Channel to a repairing yard on the Thames where preparations have been made to reconstruct the ship.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Business in engineering steel and armaments shows no marked change, although the probability of an early peace has caused somewhat of a flutter among employers and workmen alike, and considerable speculation as to what will happen in the changing-over period. No very clear idea is expressed as to what will be the position of the steel trade when hostilities cease. Stocks of steel and steel products throughout the world are depleted, and according to the ordinary law of economics a brisk business should follow the removal of the existing artificial restrictions. The present inflated prices, however, will cramp the market in many directions, and consumers will be cautious not to be caught with big stocks. At present in some departments there is a falling-off in employment, due chiefly to over production of special qualities, such as aeroplane and similar steels, restrictions of export and like causes. Export certificates, however, are being more freely granted, and a good trade done with South Africa and South America and India. Manufacturers of engineering tools are still working at high pressure, but the production, with the present depleted staffs, shows no sign of overtaking the immense demand. The removal of the embargo on rustless steel has brought that material again into prominence. It is at present used for many purposes in aeroplanes, gun parts, &c., where its rustless quality is invaluable. The Government have now agreed to ration a portion to the cutlery trade for stainless knives, and it is expected that the material will in the early future be found useful in certain parts of agricultural machinery. Agricultural and garden tools continue in brisk demand for both home and Army requirements. The inquiry for trenching tools has increased considerably since the arrival of the American troops in Europe. The seasonal demand for scythes and sickles has this year been exceptionally heavy, and has taxed the makers far beyond their productive capacity.

South Yorkshire Coal Trade.—There has been little change of importance on the Coal Exchange during the week, there being practically nothing to offer on the open market. In house coal the position is as tight as ever. The quantity allocated to the Metropolitan area is short of requirements for current orders. The demand continues at a high level, and merchants complain of their inability to deal with the orders on hand. A material shortage is also reported from both the southern and eastern counties. Industrial fuels are in active request. Collieries are fully occupied in dealing with Government and contract orders, and when these are satisfied there is no free coal left. The export trade is limited to the requirements of allied countries, there being no supplies for neutral markets. Cokes of all descriptions are actively sought after, and maximum prices are ruling. Quotations:—Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

Importers and the Ministry of Munitions.—The Minister of Munitions desires to call the attention of importers to the fact that the issue of import licences by the Board of Trade does not exempt importers from the necessity of obtaining any further licence or permit from the Ministry of Munitions which may be necessary by virtue of any order or regulation relating thereto.

A Large Cargo Carrier.—The Greenock and Grangemouth Dockyard Company launched on October 23 the largest vessel they have yet constructed, the Clan MacWilliam, a handsome cargo carrier of 10,200 tons deadweight. She is 423 ft. long and 56 ft. broad, with 26 ft. 10 in. cargo depth. She is built on the Millar system of longitudinal bottom and deck combined with transverse side framing. This method of construction is designed to give a stronger ship, with clearer hold space, and greater cargo-carrying capacity for the same displacement. She will carry ordinary cargo on her owners' regular service.

Increased Use of Pneumatic Riveting Tools.—News of the rapidly-increasing use of pneumatic riveting tools comes from both Clyde and Tyne areas. It has been one of the most marked features of the work of the Clyde shipyards during the last two or three months, and by the end of the year the extended use of these important tools will be reflected in the greater output of vessels on both the upper and lower reaches of the river. Most of the yards have now installed the necessary compressing apparatus. Thanks to the new arrangement for levelling up the wages of the men while they are learning to operate the machine, there has been no scarcity of willing workers. One important firm last week completed arrangements for doubling their present holding of pneumatic tools and expect no difficulty in securing the necessary number of riveters. In the graving docks and repairs establishments on Tyneside 480 pneumatic riveting hammers are now in use. Mr. G. J. Rowe, Boilermakers' delegate, says, "As fast as the makers can turn the tools out they are being utilised by our members in this district. All prejudice against them has completely broken down, and I do not anticipate the slightest trouble in the future as far as the men are concerned."

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Makers of Cleveland foundry iron are hesitating to book orders, and a large proportion of the November allocations have not yet been placed, producers pointing out that it is little use committing themselves to contracts they see little or no likelihood of fulfilling. Forge iron, which until quite recently was very plentiful, is now by no means so easily obtained. The main cause of complaint, however, is the truck shortage. At some of the works supply has been a trifle better in consequence of strong representations of traders, but at other establishments the situation is as bad as ever, and on the whole, the shortage is still very pronounced. Wherever practicable lighters are used to deliver iron, and steamers are being more extensively used for despatch to Scotland and East Coast ports. With tonnage for abroad coming forward fairly well, shipments to the Allies are maintained on a substantial scale, and occasionally a parcel is released for neutral destinations. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are 122*s.* 9*d.* and No. 1 is 127*s.* 9*d.*

Hematite Iron.—The position as regards East Coast hematite is satisfactory, having been much relieved by the more extensive use of basic iron for steel-making. Furnaces on both hematite and basic appear to be working well. There is no real shortage of either quality, but at the same time, the output is passing promptly into consumption. Needs of home consumers of hematite are adequately met, and fair quantities are available for despatch to the Allies. Nos. 1, 2 and 3, 122*s.* 6*d.* for home use and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—In finished iron and steel some inquiry on post-war account is reported. There is, however, no abatement in pressure for delivery, and manufacturers appear to be keeping pace with the requirements. Firms are chiefly engaged on the production of shipbuilding material and constructional steel, and the opinion prevails that the transition from war to peace will not diminish to any great extent the demands now being made on local works. Supplies of material direct to shipyards, and also to bridge yards, where fabricated ships are being constructed, are heavy. Prices, all round, are fully maintained. Current quotations in the home trade are as follow:—Common iron bars, 4*l.* 15*s.*; best bars, 15*l.* 15*s.*; double best bars, 16*l.* 15*s.*; triple best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.* 10*s.*; steel hoops, 18*l.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*—all f.o.t. at works. There are no fixed prices for export, but they may be given as approximately 40*s.* above home quotations.

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough for the month of October were considerably below what was looked for, the aggregate being little better than the total for September which, with one exception, was the lowest since the outbreak of war. Last month's loadings of pig-iron amounted to 29,092 tons, as compared with 29,579 tons for the preceding month. Only 173 tons of manufactured iron were shipped, as against 1,160 tons in September. Steel cleared amounted to 9,357 tons, as compared with 5,578 tons for the previous month. Coastwise shipments of pig-iron for October were returned at 8,281 tons, as against 6,166 tons for September, and foreign clearances at 20,811 tons, as compared with 24,001 tons for the previous month. Clearances of manufactured iron and steel coastwise last month totalled 1,141 tons, whilst 8,389 tons went abroad.

Coke.—The coke position shows some improvement. Delivery to local blast furnaces is satisfactory, and whilst needs in other directions are not fully met, supply is better. Average furnace coke is 33*s.* at the ovens; and quality low in phosphorus, 35*s.* 6*d.* at the ovens. Foundry coke for shipment to neutrals is put at 65*s.* f.o.b.

Institution of Electrical Engineers: Model General Conditions for Contracts.—In the case of contracts made on and after January 1, 1919, the amounts of the instalments of the retention money specified in Clause 24 (2) will be altered from 10 per cent. and 10 per cent. to 15 per cent. and 5 per cent. respectively.

Waste in the Use of Fuel Oil.—An investigation recently conducted by the United States Bureau of Mines in co-operation with the Fuel Administration, says *The Iron Age*, New York, has furnished data for the statement now made that fuel sufficient to operate the railroads of the country for one month is being wasted every year by the users of fuel oil. Stated in other terms, the waste in the use of fuel oil is five times the fuel necessary for all the Federal Government consumption, including that of the Navy and Army. Last year's consumption amounted to 160,000,000 barrels of fuel oil, and 40,000,000 barrels, or one-fourth of the entire amount was wasted. At 3·50 dols. per barrel, this represents 140,000,000 dols. As one result of the investigation, a handbook for boiler plant and locomotive engineers on the efficient use of oil as fuel has been issued by the Bureau of Mines, giving instructions to all operators of oil-burning plants.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The military and international situation—notwithstanding the prospect of peace in the near future—in no way detracts from the position so far as the manufacture of steel in the West of Scotland is concerned. Every mill is running to its fullest capacity, and Government orders are being turned out with all possible despatch, the result being that the home demands are now well in hand, with material to spare, for export trade, were it considered advisable to set this going once more. At the moment, however, some limited consignments to France, Italy and the Indian State Railways represent the entire overseas' shipments. So far as the immediate future can be reckoned upon, there is little fear of any slackness, as manufacturers are just awaiting the termination of their war contracts to turn on to the work which has been requisitioned from time to time during the past few months by their ordinary commercial customers. The orders already accepted on these conditions are sufficient to keep things going until business can be reorganised on a satisfactory basis. Numerous inquiries too are coming to hand from France and Belgium for the constructional material necessary to repair the ravages of war. Meantime the requirements of the shipyards are a heavy item, and so also are the light railway sections which are in such constant demand for war purposes.

Malleable Iron Trade.—In the malleable iron trade, war work still usurps the entire time and attention of makers, and mills are running without cessation rolling the bars required for the many orders which have been booked. This work of national importance is so clamant that, although persistent inquiries have been made by ordinary mercantile consumers for material to be delivered after the war, these cannot be considered meantime. For the same reason requisitions for export are being declined practically every day. Only high priority claims can be dealt with, alike in the iron and the steel departments.

Scotch Pig-Iron Trade.—Pig-Iron of all grades continues in heavy demand and smelters find themselves quite unable to deal with all the business for which consumers are pushing. War work swallows up the entire output and very little is available for export. The shortage of coal still constitutes a situation of much gravity, but even with this the output is being steadily maintained. As things are there seems little chance of any falling-off either in demand or supply for a considerable period to come.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on the afternoon of the 4th inst., His Grace the Duke of Northumberland in the chair. Special thanks were returned to Mr. R. Pearce for his donation of 100*l.* to the Research Fund. It was announced by the secretary that the Christmas course of Juvenile Lectures would be delivered by Professor D'Arcy Thompson, the subject being "The Fish of the Sea."

THE LATE MR. EDWARD BENNIS.—We regret to have to announce the death of Mr. Edward Bennis, the principal, founder and managing director of the firm of Ed. Bennis and Co., Limited, which occurred at his residence, Beech Hill, Astley Bridge, Bolton, on October 29. Mr. Bennis was born in Limerick in 1838, and was educated at the Quaker College of Newtown, Waterford. On leaving the college, he was apprenticed to Mr. Thomas Chandler, of Balls Mills, Waterford; he subsequently entered the service of Mr. Peter Moore Fisher, of Pilton, Cork. He afterwards started in business on his own account, and within a few years had acquired a competence which enabled him to retire; he then lived in Paris and in London. Some years later, he entered business afresh and took an active interest in the mechanical firing of boilers, joining Mr. Dillwyn Smith, of Philadelphia. Works were started in Liverpool, but Mr. Bennis soon came to the conclusion that the system which provided only for throwing the fuel on the fire was incomplete, and that better results were possible if an efficient furnace were devised by which the fire-bars could be automatically freed from clinkers, whilst the machine distributed the fuel over the fire. He invented a self-cleaning furnace; a great increase in evaporation was obtained in boilers fitted with his apparatus, the smoke nuisance was lessened and a considerable economy in fuel was effected which soon paid for the machinery. Mr. Bennis continued to improve his machine and established his works in Bolton, which was a better centre for his operations. A new principle of firing was later introduced, in which the coal was spread over the fire by the action of a striker which distributed it intermittently. At the Manchester Sanitary Exhibition, 1882, a competition of mechanical stokers was held, at which Mr. Bennis won the medal issued for merit on the points of smoke abatement, power and efficiency. Later, at the Yorkshire Jubilee Exhibition, he received the gold medal, which was awarded for the best system of machine-firing. More recently, a newer system has been introduced by Mr. Bennis, in conjunction with his son, in which all the advantages of forced draught, machine-firing, induced draught and self-cleaning furnace have been concentrated. The works at Bolton being found too small in 1904, a site for a new factory was obtained at Little Hulton, near Bolton, where large works have been put down. The history of Mr. Bennis, of which a very brief abstract is given in the foregoing, is a record of high endeavour and of work well done.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 8, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: (1) "Low Voltage Arcs in Metallic Vapours," by Professor J. C. McLennan, F.R.S.; (2) "Relativity and Gravitation," by Mr. W. Wilson, D.Sc.; (3) "A Demonstration of Experiments, illustrating Colour Blindness," by Mr. Charles R. Gibson, F.R.S.E.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 8, at 6.15 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne, the following Lecture will be given: "Electric Welding for Shipbuilding Purposes," by Mr. W. S. Abell, M.Eng., M.N.E.C. Inst., Chief Ship Surveyor of Lloyd's Register.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, November 9, in the Assembly Room of the Cycling Club, the second lecture of the session will be given by Mr. W. Bowen, of Leeds. Subject: "Pyrometers and other Instruments in Connection with Heat Treatment." Chair to be taken at 6.30 p.m. by the president, Mr. H. Widdop.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday Evening, November 9, at the Grand Hotel, Aytoun-street, when a paper entitled "Workshop Measurements, with Special Reference to the Limit System," will be read by Mr. W. F. Rhodes, M.I.Mech.E. (Member). The paper will be illustrated by lantern slides. The chair will be taken at 6.30 p.m.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Saturday, November 9, at 3 p.m., at the Danum Hotel, Doncaster. Business:—Paper on "Some Economic Considerations in Coke Oven Practice," by Mr. W. Colquhoun. The following papers, which have recently appeared in the Transactions of the Institution of Mining Engineers, vol. lv., Part 4, will be open for discussion: "Terrestrial Magnetism in Relation to Mine Surveying," by Mr. C. Chree, Sc.D., LL.D., F.R.S.; "The Effects of Dust-inhalation," by Mr. John Scott Haldane, M.D., F.R.S.; "The Origin of Blackdamp," by Mr. J. Ivon Graham, M.A., B.Sc.; "The Flow of Air through Small Coal and other Broken Material: Report to the Doncaster Coal-Owners' Committee," by Mr. John T. Storrow.

THE SURVEYORS' INSTITUTION.—Monday, November 11, when the president, Mr. John Hubert Oakley, will deliver an Opening Address. The chair will be taken at 5 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, November 12, at 7.15 p.m., at the Mining Institute, Neville-street, Newcastle-on-Tyne. Paper on "The Design of High-Speed Steam Turbines," by Mr. Ward.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, November 12, at 7.30 p.m., in the Rooms, 207, Bath-street, Glasgow, when the chairman, Mr. J. F. Nielson, will deliver his Inaugural Address.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Tuesday, November 12, at 3 p.m., at the Holborn Restaurant (Caledonian Room), a meeting will be held to discuss Fuel Economy.

THE INSTITUTION OF MECHANICAL ENGINEERS.—General meeting, Friday, November 15, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Adjourned discussion on the following papers: "A Law Governing the Resistance to Penetration of Metals which are Capable of Plastic Deformation, and a New Hardness Scale in Fundamental Units," by Professor C. A. Edwards, and Mr. F. W. Willis, of Manchester; "The Value of the Indentation Method in the Determination of Hardness," by Mr. B. G. C. Batson, of Teddington, Associate Member, and "The Ludwik Hardness Test," by Dr. W. Cawthorne Unwin, F.R.S., of London, Past-President. Also (if time permits) "Electric Welding," by Mr. T. T. Heaton, of Uxbridge, Member.

COMMERCIAL AEROPLANES.—Mr. F. Handley Page, writing in *The Empire Review*, states that reduction of the weight of the aeroplane itself and its engines has now become a fine art, and everything possible is done in this direction, as each pound saved means a pound more load—at present of bombs and ammunition. Each machine must have at least one pilot, and every passenger-carrying machine at the service of the public ought to have two pilots in case of sickness of the one actually in charge. The fuel is a very big item. Since the main asset of the aeroplane is speed, it must not be hampered by delays for refilling tanks or too many stops *en route* and, taking everything into consideration, it would appear that it ought to carry petrol and oil for about 400 miles run. All this unremunerative load constitutes a very large proportion of the total lift of the machine, and as it naturally requires very considerably more power to maintain a ton in the air than to drag a ton on the ground (the ratio is of the order of 10 to 1), it follows that the amount of revenue-earning load carried per horse-power is many times less. As power is paid for in fuel, it makes the running cost per unit of revenue-earning load very much higher. On the other hand—an aeroplane service does not call for one tithe of the capital outlay needed for a railway or to maintain a steamship service. The overall result is that a service of aeroplanes can be maintained and operated at a profit on freight charges corresponding to about 1½*d.* per pound per 100 miles for goods, and about 3*d.* per mile for passengers.

THE CONDENSATION OF ZINC FROM ITS VAPOUR.

THE exceptional conditions of the metallurgical reduction of zinc by carbon are fairly well understood, but very difficult to meet. Zinc is only reduced by coal as vapour at a temperature above its boiling-point which lies near 1,000 deg. C.; the zinc vapour has to be condensed at temperatures above the melting-point of the metal, 420 deg. C.; at lower temperatures zinc falls out as fume or blue powder, impure with oxide. If oxygen could altogether be excluded, the condensation difficulty would be diminished, but the maintenance of certain temperature limits is difficult, and the troubles are great in electric arc furnaces. The zinc vapours are, moreover, easily oxidised also by water vapour and even by small percentages of carbon dioxide. This was known, but the investigation of Professor C. H. Fulton, of Cleveland, Ohio, throws some further light on the subject (Bulletin, American Institute of Mining Engineers, August, 1918 pages 1375 to 1394). He made briquettes of calamine, coke and pitch, baked them at 500 deg. C., and then distilled them in an electric furnace having previously expelled other gases from the apparatus by a current of nitrogen; his condenser was a long glass tube, and the escaping gas and vapours were collected over water.

The nitrogen feed—in some cases the nitrogen was replaced by hydrogen—was stopped when the distillation was seen to have commenced. But it was noticed that the gases collected contained considerable portions of nitrogen and also of hydrogen. Some nitrogen might have leaked into the apparatus; that possibility was excluded in the case of hydrogen, however. Both these gases are known to occur in the zinc retort and are supposed to diffuse through the hot retort walls. But Fulton points out that in coke ovens nitrogen, hydrogen and methane are liberated, especially at the highest temperatures, and the briquetted charge in his apparatus, as well as the coal of the zinc retort, would be turned into coke. The hydrogen reduces zinc oxide at comparatively low temperatures; thus water is formed which is decomposed by the hot coke and gives hydrogen again and also oxygen. The normal combustion product of coal in the retort is carbon monoxide; by reaction with the zinc oxide, however, zinc and carbon dioxide are formed. All these reactions are reversible, moreover, and in the laboratory carbon monoxide is sometimes prepared by passing the oxide over red-hot zinc; which is turned into oxide. Fulton heated lumps of metallic zinc in another apparatus and passed either pure CO, or pure CO_2 or mixtures of the two gases over the metal, measuring the temperatures with the aid of thermocouples. Under different conditions he obtained liquid zinc, or feathery crystals of the metal, or bright globules or globules slightly coated with oxide, which would not unite, and also black deposits of carbon.

From these and other experiments, made with tubular carbon furnaces and with graphite retorts, Fulton concludes that, in addition to keeping the air out of the retorts or distillation vessels, one of the chief points is that a uniform temperature should rapidly be produced and should be maintained in the retort, no part of the retort and charge to be below 950 deg. or 1,000 deg. C. The resistance furnace of Fulton, which is covered by several recent patents, was described in *Metallurgical and Chemical Engineering* of May last, we should add. The finely-disintegrated ore or blue powder is briquetted with coke and tar at pressures up to 1,000 lb. per square inch into rods of 12 in. diameter, 6 ft. long, which are baked to coke the coal and mounted on an electrode disc, which afterwards forms the bottom of the furnace, the rods serving as resisters. Electrode connections having been fitted to the rods at top and bottom, the preheated furnace shell is lowered over the rods, and the temperature is raised by the current to 800 deg. C. and then rapidly pushed up to 1,000 deg. and higher; the gases, zinc and CO, are drawn off at the top and bottom of the furnace into the condenser.

QUEENSLAND IRON AND STEEL PRODUCTION.—In the final report of the Queensland Royal Commission on the Steel and Iron Works, the Commissioners say: "We are in a position to state we have collected sufficient data to justify us in recommending that the Government establish an up-to-date plant for the manufacture of commercial pig-iron at a cost of approximately 100,000*l.* For this sum a modern blast furnace with a capacity of 100 tons of iron ore per day can be established, and it can be kept fully employed for twenty years in the smelting of ore from one mineral area alone." The Commission, in its final recommendation, suggests the State should encourage the manufacture of steel rails, and they therefore unanimously recommend that the State should proceed immediately with the erection of a furnace with a capacity of, say, 150 tons of ore per day, together with an extensive by-product recovery, coke ovens and mine equipment, at an initial cost not exceeding 150,000*l.*, further sums to be expended if circumstances warrant the extension of the work. The report also adds that a thoroughly qualified expert with business and administrative ability trained in metal science and engineering, and having a practical knowledge of modern iron and steel works, be appointed, and as such he be empowered to choose a most suitable site on which the plant should be erected; also that a general manager be appointed by the Government to make investigations on the advisability of establishing a State steel manufacturing works, on the cost of such works and on the capacity of the markets in Queensland for iron and steel, and the possibility of a market for export beyond the State in general.

REINFORCED CONCRETE RESERVOIRS AT MONTEVIDEO.

THE HON. R. C. PARSONS, M.A., M.INST.C.E., ENGINEER, LONDON.

(*For Description, see page* 515.)

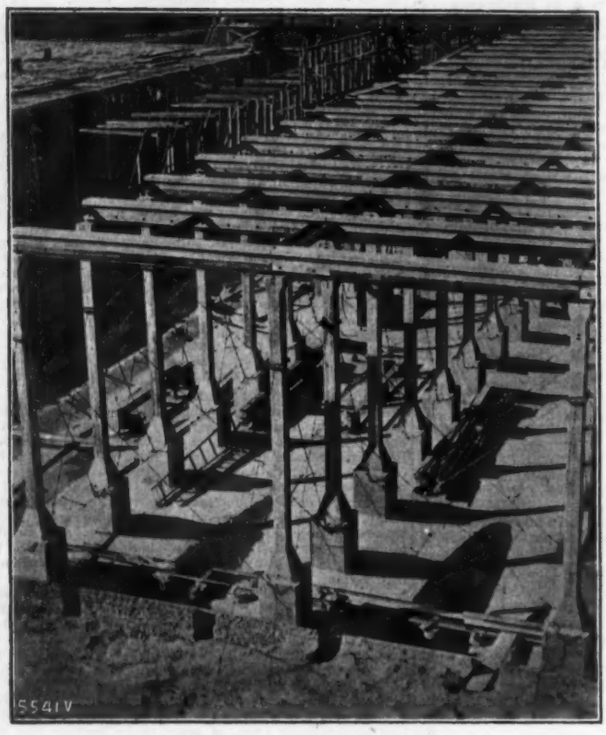


FIG. 66.

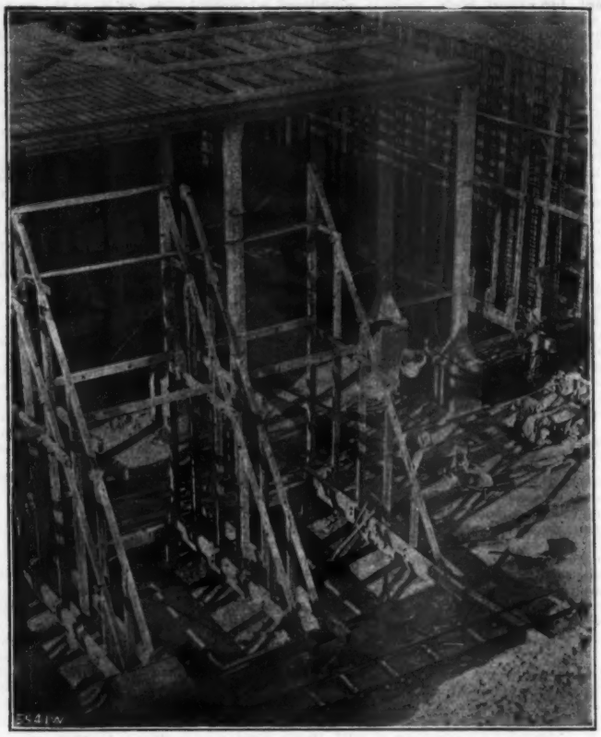


FIG. 67.

FIG. 68.

FIG. 69.

75-TON FLOATING CRANE AT THE CANADI VIC

(For Des... Page 5

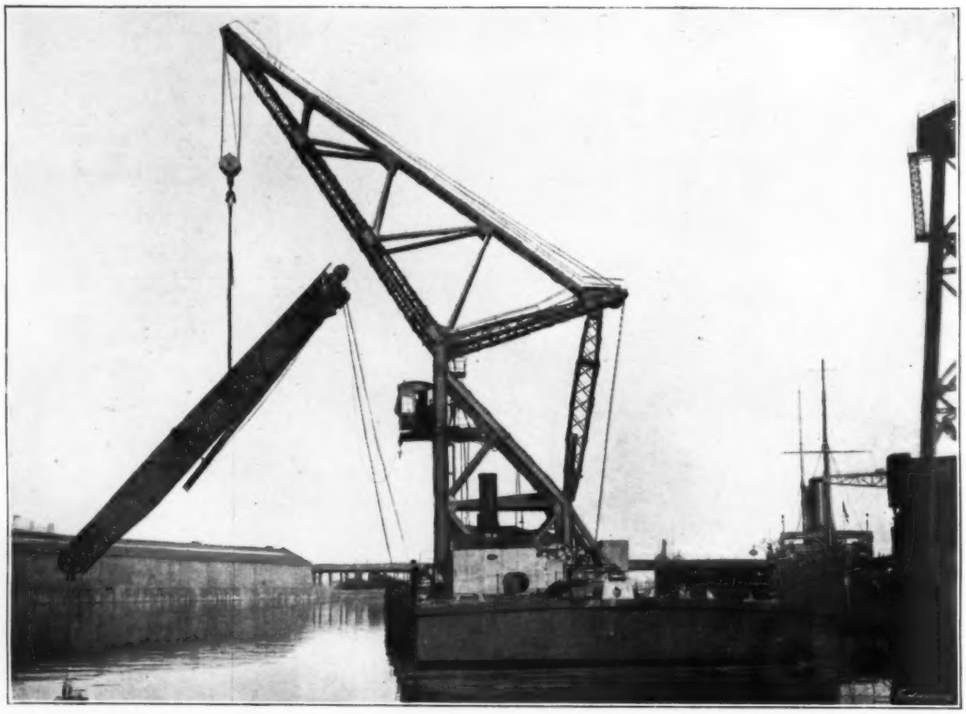


FIG. 14.

Fig.15. SECTION THROUGH FRAME No 46.

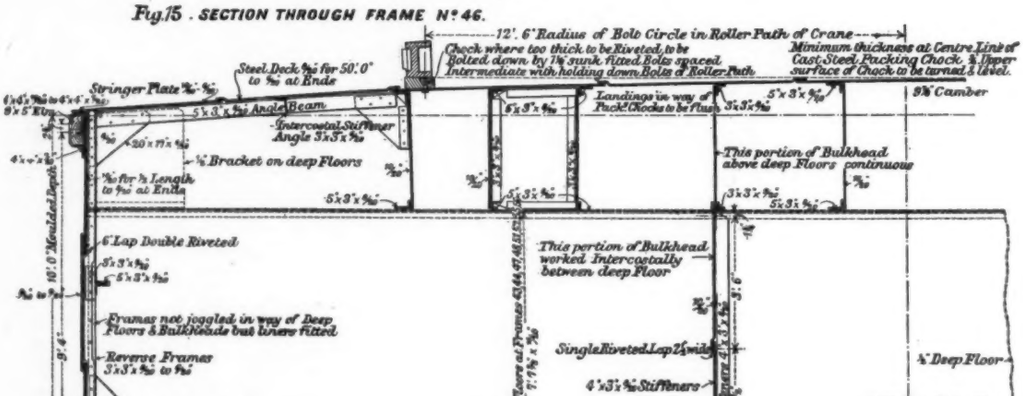

12'. 6" Radius of Bolt Circle in Roller Path of Crane
Chock where too thick to be Riveted, to be Bolted down by 1⅛ sunk, Fitted Bolts spaced Intermediate with holding down Bolts of Roller Path.
Minimum thickness at Centre Line of Cast Steel Packing Chock. ¾ Upper surface of Chock to be turned & level.
Steel Deck ⅝ for 50'.0" to ⅝ at Ends
Stringer Plate ⅞
9⅜ Camber
5" x 3" x ⅝ Angle Beam
Intercostal Stiffener Angle 3" x 3" x ⅝
Landings in way of Pack.d Chocks to be Flush
5" x 3" x ⅝
½ Bracket on deep Floors
This portion of Bulkhead above deep Floors continuous
⅝ for ½ Length to ⅝ at Ends
6" Lap Double Riveted
This portion of Bulkhead worked Intercostally between deep Floor
Frames not joggled in way of Deep Floors & Bulkheads but liners fitted.
Reverse Frames 3" x 3" x ⅝ to ⅞
Single Riveted Lap 2½ wide
4" Deep Floor
4" x 3" x ⅝ Stiffeners
21" x 21" x ⅝ to ⅞
5" x 3" x ⅝ to ⅞
23" x ⅝ Foundation Plate Frames 43-56 Intercostal between deep Floors
Ordinary Floors 15" x ⅝ to ⅞ Flanged.
Frames 4" x 3" x ⅝ to 4" x 3" x ⅝
2½ Above Base
21'. 6" Half Moulded Breadth
⅝ for ½ Length to ⅝

Fig.16. SECTION THROUGH FORE & AFT ENDS.

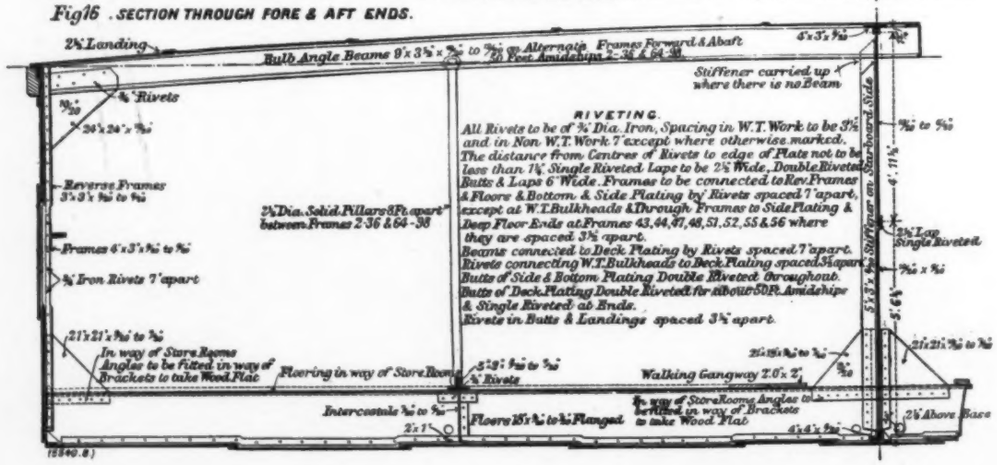

2½ Landing
Bulb Angle Beams 9" x 3½ x ⅝ to ⅞ to Alternate Frames Forward & Abaft 70 Feet Amidships 2-36 & 64-38
6" x 3" x ⅝
Stiffener carried up where there is no Beam
⅝ Rivets
RIVETING.
All Rivets to be of ¾" Dia. Iron, Spacing in W.T. Work to be 3" and in Non. W.T. Work 7" except where otherwise marked.
The distance from Centres of Rivets to edge of Plate not to be less than 1¼". Single Riveted Lape to be 2½" Wide, Double Riveted Butts & Laps 6" Wide. Frames to be connected to Rev. Frames & Floors & Bottom & Side Plating by Rivets spaced 7" apart, except at W.T. Bulkheads & Through Frames to Side Plating & Deep Floor Ends at Frames 43, 44, 47, 48, 51, 52, 55 & 56 where they are spaced 3½" apart.
Beams connected to Deck Plating by Rivets spaced 7" apart.
Rivets connecting W.T. Bulkheads to Deck Plating spaced 3" apart.
Butts of Side & Bottom Plating Double Riveted throughout.
Butts of Deck Plating Double Riveted for about 50 Ft. Amidships & Single Riveted at Ends.
Rivets in Butts & Landings spaced 3½" apart.
Reverse Frames 3" x 3" x ⅝ to ⅞
2⅜ Dia. Solid Pillars 8 Ft. apart between Frames 2-36 & 64-38
Frames 6" x 3" x ⅝ to ⅞
¾ Iron Rivets 7" apart
21" x 21" x ⅝ to ⅞
In way of Store Rooms Angles to be Fitted in way of Brackets to take Wood Flat
Flooring in way of Store Rooms
Walking Gangway 2'. 0" x 2"
Intercostals ⅝ to ⅞
Floors 15" x ⅝ to ⅞ Flanged
In way of Store Rooms Angles to be Fitted in way of Brackets to take Wood Flat
2½ Above Base
(5840.B.)

Fig.18.

Fig.20

VICKERS SHIPBUILDING WORKS, MONTREAL.

(See Page 518.)

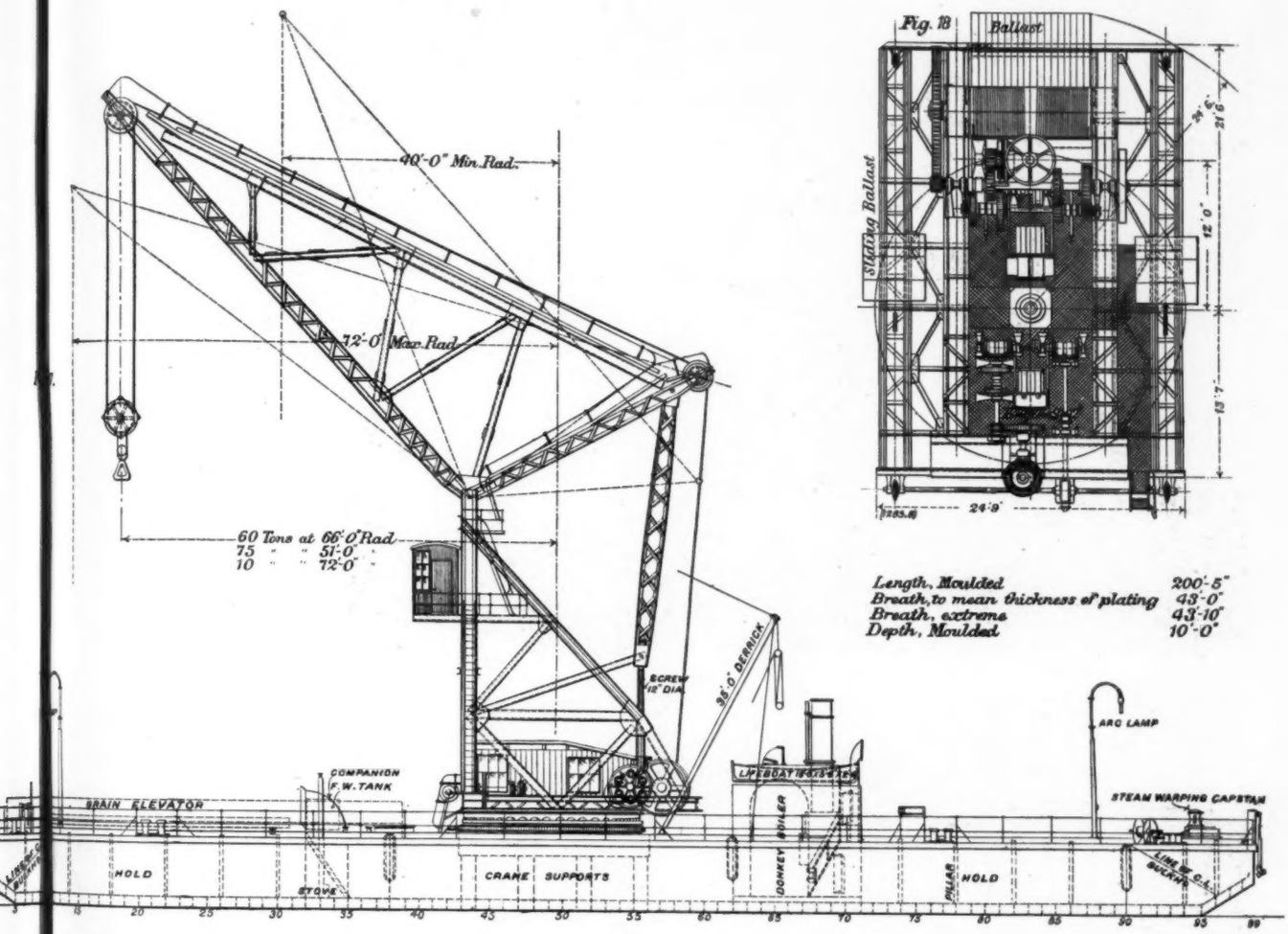


Fig. 18

Length, Moulded	200'-5"
Breath, to mean thickness of plating	43'-0"
Breath, extreme	43'-10"
Depth, Moulded	10'-0"

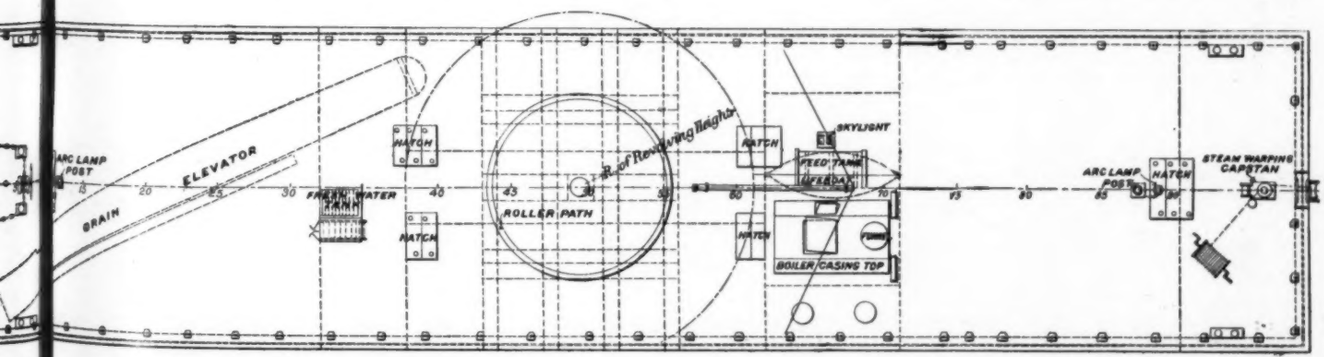
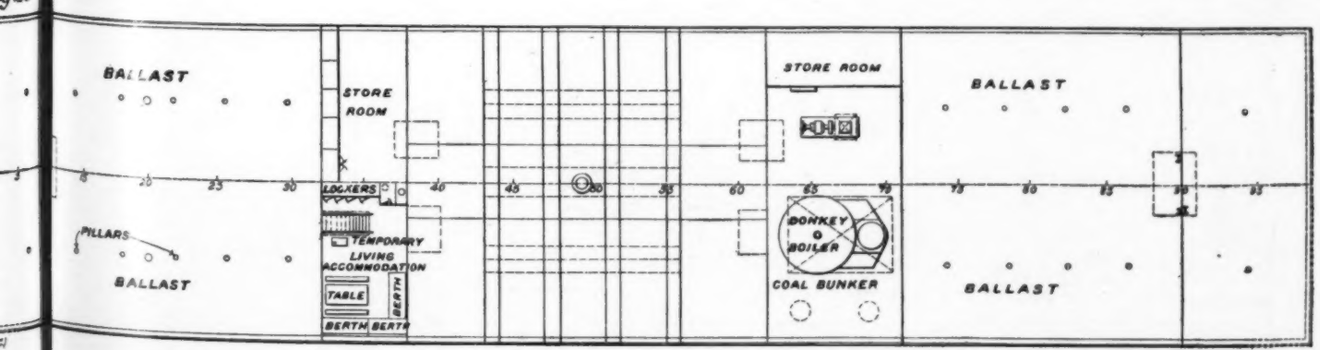


Fig. 20



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 4d. to 5d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 527.

ENGINEERING.

FRIDAY, NOVEMBER 8, 1918.

THE FUTURE OF OUR RAILWAYS.

It is a commonplace that in most respects the outbreak of the war found this country in a condition of complete unpreparedness. Our small army, which in very virtue of its smallness should have been the best equipped in Europe, proved to be woefully deficient in artillery, machine guns, and aeroplanes. Our supply of shells was hopelessly inadequate, and the design and specifications of these shells and their fuzes might almost have been purposely planned to make the maximum of difficulty in extemporising additional sources of supply. All these lapses had to be paid for in the ghastly currency of human lives. With so much to regret it is a matter for satisfaction that in one important field of action we have no lack of foresight to reproach ourselves with. As stated in the admirable presidential address which Sir John A. F. Aspinall delivered at the Institution of Civil Engineers last Tuesday evening, the operation and control of our railways in time of war was thoroughly thought out in the years 1912-13 by a carefully selected committee of Railway General Managers in combination with the military authorities. When, in 1914, the crisis ensued a few telegrams sufficed to constitute the railway executive committee which took over the operation of the railways of the Kingdom and brought into action the already completely worked out plans for the transport of our expeditionary force to its ports of embarkation. Although details are yet unpublished it is known that this was effected with the utmost celerity and smoothness. There was not one instance of troops being kept waiting for their transport, the train was invariably ready before the men.

This committee has continued to operate our railways to this day. With depleted staffs, with a largely reduced rolling stock, fewer engines, and with permanent way and plant of all kinds but indifferently maintained (in comparison with pre-war standards), our railways have during these strenuous years carried the heaviest traffic in the whole course of their history. Much credit for this must undoubtedly be given to the intelligence of the employees as a whole in realising that a Hun victory would hit the proletariat harder than any other section of the community. The best efforts of loyal labour would however have yielded but a sorry harvest had not the government confided the control of the lines to the same experienced chiefs who had been responsible for the prosperity of our railways in times of peace.

Recruited in a field in which initiative is more highly valued than seniority or political pull our railway administrations have thoroughly demonstrated their worth, and the evidence of the value of their methods of selection and promotion has been so marked, that, as is well known, directing heads for many other important national undertakings have been sought for in and secured from the ranks of our railway officials.

The unity of control thus established on railways to meet the exigencies of war has naturally led to discussions as to how far it will be desirable to continue this status on the conclusion of peace. By a curious but, in the case of those concerned, a characteristic perversion of logic, the endeavour has been made to utilise the very success with which our privately owned and operated lines have met a national emergency, as an argument in favour of nationalisation. As matters stand nationalisation would possibly be welcomed by the shareholders, and the policy is in consequence apparently a little less in favour in labour circles than formerly. It will be remembered that the usual annual resolution in favour of railway nationalisation was materially modified at this year's Trades Union Congress.

All sorts of publicists, from "guinea pig" peers and crank inventors to popular novelists and hack journalists, have, during the past few months favoured us with their views, as to how our railways must be equipped, operated and controlled in the future. After this surfeit of uninformed if ardent advocacy, it is a great relief to meet with such a suggestive and instructive a pronouncement on these matters as is to be found in Sir John A. F. Aspinall's address, which we publish in full elsewhere in our present issue. As general manager of the Lancashire and Yorkshire Railway, and member of the Railway Executive Committee, Sir John's qualifications for the task he set himself are unquestionable and his views will be eagerly perused by all anxious to ascertain facts as they are, and not merely in search of arguments in support of political or economic theories.

One very important point brought out in the address is the need for drastic changes in the structure gauge and loading gauges of our railways. We have, nominally, a standard loading gauge, but it by no means follows that any vehicle from one line can safely be despatched over the metals of all others. We suffer from the fact that we were the pioneers of railway enterprise. From this circumstance we reaped some extraordinary advantages, but there have been some accompanying drawbacks. Platforms and tunnels in those far distant times were built with too conservative ideas as to the dimensions of the stock it would be desirable to provide for in the distant future. Similarly many bridges, fully adequate to the axle loadings even of 25 years ago, are now too weak to carry modern rolling stock. Unfortunately as the incident of the Charing Cross bridge has demonstrated, Parliament is by no means anxious to help the companies in works of rebuilding and reconstruction. Yet in spite of this ill will or indifference, our leading companies have managed to effect much in the matter of widening structural and loading gauges and in strengthening bridges. The result is, however, that the area within which the most up-to-date stock can be operated is limited. There are, Sir John Aspinall stated, about 100 standard gauge railways in this country. Selecting a particular loading gauge (not the largest in the use) it appears that only eighteen of these railways could accept all the stock which passed this gauge.

One striking point made in the address, and one to which attention has on several occasions been directed in our columns, is that were the channel tunnel constructed it would be necessary to tranship goods at either the Dover or the Calais portal of the tunnel, since our railways have a substantially smaller loading gauge than the continental lines, and thus whilst our stock can run in France, French stock is useless here.

It is to be hoped that Sir John Aspinall's views on the loading gauge question may receive full attention from the railway authorities in Australia, who are concerned with the establishment of uniformity of gauge in the Commonwealth. In discussing this matter, we have over and over again urged the necessity of giving particular attention to the fact that the carrying power of a railway is practically controlled by its loading gauge, and that, in adopting any standard gauge of lines for the several Colonies, every care should be taken that the capabilities of that gauge should be utilised to the uttermost.

It is evident that much must be done in the immediate future to widen loading gauges and to strengthen the bridges on our less progressive lines

Much work of this character has had to be done in America during recent decades. As Sir John pointed out axle loads there have risen from the ten tons or fifteen tons of thirty years ago to a present maximum of thirty-five tons. Fifteen years ago the average weight on drivers of 36,000 American locomotives was 85,000 lb. and the tractive effort was 19,000 lb. In 1915 the average weight on drivers of 62,000 engines had become 135,000 lb. and the average tractive effort 30,500 lb., whilst the Mallet engines gave figures of 350,000 lb. on drivers and exerted a tractive effort of 79,000 lb. To accommodate this stock a vast expenditure has been necessary on heavier rails and stronger bridges, but the result of the adoption of grant trains is that freight is handled in America at a lower cost than in any other country in the world.

It is highly important that freight charges here should be reduced to a minimum although of course, our average haul being so short, railway freight charges do not bulk very largely in the total costs of production. One great difficulty met with in reducing freights lies in the fact that the Railway Commissioners discourage experimental freights. It is in actual practice, if not in theory, impossible to try a low freight provisionally to see whether it may in this way be possible to develope a sufficient volume of traffic to make the low rate pay. Once granted, a low rate can only be increased again after prolonged negotiations. Another difficulty in lowering railway freights here lies, as Sir John pointed out, in the fact that the customers of our railways insist on celerity of service. This has the great advantage of reducing the amount of stock it is necessary for them to keep in hand, but it makes full car loads impracticable. Goods despatched one day are commonly delivered the next. Sir John Aspinall suggested that an improvement might be effected if a considerable "differential" was allowed between the charges for "slow freight" and "express delivery." This has been the practice in Germany and a profitable business was done there by forwarding agents, in collecting together parcels for different consignees in the same areas, so as to make up a full car load. Deliveries were, of course, greatly delayed, but as Mark Twain observed many years ago, the German slow freight service was at any rate "quicker than a glacier."

Sir John Aspinall also called attention in his address to the necessity of a better port and harbour equipment. At some ports there are facilities for handling 20-ton coal wagons, but at many berths at the same ports 10-ton wagons only can be dealt with. The shipper cannot tell *a priori* at what berth the ship he is supplying will be stationed, and hence plays for safety by keeping to 10-ton wagons, which, in addition to other drawbacks, occupy 42 per cent. more of the very valuable siding space at the docks. Another dock difficulty on which he touched is the necessity which arises of handling goods more than once. In the case of imports the Customs authorities have to examine every package, whilst in the case of exports, goods cannot be taken on board ship in rotation as received at the docks, but must be stowed in due and regular order for considerations affecting the seaworthiness of the ship.

Probably it came as a revelation to most of his hearers that very nearly one-half of the wagons here are privately owned. This circumstance makes it difficult, indeed, normally impossible, to secure back freights, although it must be admitted that as most of these privately-owned wagons are used for coals or minerals the possibility of back freights would, at the best, be small. Nevertheless this fact of private ownership does very materially reduce opportunities for economies.

The President's views as to the method by which the general electrification of our railways will be brought about are of great interest. He thinks that this will come about by the gradual extension, further and further from their centres, of local electrifications. Neighbouring systems will ultimately be separated by so small a gap that the bridging of this will become practically a matter of course. Where electrified local services have been installed the growth of traffic has been almost phenomenal, and the additional revenue required to pay interest on the large capital outlay necessary for the complete electrification of our railways can, Sir John considers, be best obtained by taking advantage of this fact. The scheme thus outlined is, perhaps, not heroic, but it seems to be eminently practical.

Another very interesting suggestion made in the address is that the many thousands of miles of 60 centimetre gauge line, which have been laid in France to serve our armies, should after the conclusion of peace be removed to this country, together with the rolling-stock, and used for agricultural light lines. For this scheme to be effective the hampering obstructions introduced for certain ulterior motives into the Tramways and Light Railways Acts must be abrogated, and perhaps Parliaments of the future will prove more accessible to reason in this regard than those of the immediate past, which were far too much inclined to discuss matters relating to works of *utilité publique* from the viewpoint of certain political and economic theories, than as practical propositions for increasing the wellbeing of the community at large.

THE MOTOR TRANSPORT DEPOT AT SLOUGH.

During the spring, when the Germans were pushing our armies back, and when their shells were falling into Amiens, and the menace against the Channel ports was cause for anxiety, the question of repair of motor vehicles assumed a most urgent aspect. It is well-known that we have a number of large repair shops in France, and that the rough usage of war sends a constant stream of vehicles into them. Hundreds of men are kept steadily at work fitting new parts and repairing old ones, and if, as seemed possible, many or all of the workshops had fallen into the enemy's hands, our transport departments would have been very seriously incommoded and the mobility of the army decreased. The War Office was faced with necessity of taking instant action on the assumption that the tide of German victory might overflow many of our repairing works in France, and cut the communication of others. The authorities decided, in the first place, that it was desirable to transfer the work to this country in spite of the difficulty of transport, as this area was clearly beyond the range of German invasion. There then remained the further alternative of sending the cars back to the makers for overhaul, or of establishing new works for the purpose. Without knowing exactly what reports had been received from the Headquarters Staff in France it is difficult to judge whether the decision to create new and immense works at Slough was wise or not. If the Allied line had been broken, either on our front or between us and the French, a long retreat, with the abandonment of immense stores and a considerable slice of industrial France, must have followed. We should then have had not only to repair our own cars, but also to replace great numbers lost both by us and by our Allies. How imminent was the danger of such a disaster it is impossible for an outsider to say. If it was regarded by the generals in the field as even possible there was excellent reason for taking steps in advance to meet it by the erection of new works. It was certain that all the existing factories would be filled to the doors with new cars in course of manufacture, and that they would have neither the space nor the labour for repair work.

So far we have dealt with the immediate emergency of last spring and early summer. But the trouble dates much further back, and the German menace was only the last straw in the burden laid on the mechanical engineers in the Army. In the eighth Report of the Select Committee on National Expenditure, dated August 7, it is stated: "There is now in England an accumulation of several thousand motor vehicles awaiting repair, three times as many as a year ago. In France there are almost an equal number." Clear evidence is thus afforded that our repair facilities had long been quite unequal to the strain thrown upon them, and that instead of putting damaged machines into a working condition on the spot, we were sending new ones into the field. Our manufacturing facilities managed by private enterprise were working well, but our repair plant, under military control, had proved very inefficient. This is not because there are not competent mechanical engineers in the Army; there are hundreds of them, and many of them are attached to the Mechanical Transport department. But there is no separate department of mechanical engineering in the Army, and no organisation by which the professional opinion of mechanical engineers can make itself heard. To realise what this means we have only to examine the organisation of other departments. For instance, the veterinary officers act under a Director-General, a Deputy Director-General, an Assistant Director-General, and a Deputy Assistant Director-General. Similarly the medical men are represented at the War Office by a Director-General, a Deputy Director-General, two Assistant Directors-General and five Deputy Assistant Directors-General. Even the clerical officers work under a Chaplain-General, an Assistant Chaplain-General, and a Staff Officer to the Chaplain-General. Again, with every army in the field there are important representatives of these departments and others, and when any question comes up for settlement, either on the spot or in London, the views and opinions of those who have a technical knowledge of the subject must be heard and considered. There is a continuous chain between the junior subaltern and the Director-General, and it is the fault of the latter if the War Office has not the best professional opinion put before it in a way that cannot be ignored.

There is, as we said, no department of mechanical engineering in the Army. There is a department of Supplies and Transport, with several grades of directors, and to this large numbers of mechanical engineers have been attached. The repair work of mechanical vehicles is in the hands of the Army Service Corps, and they have naturally appointed mechanical engineers to carry it out. But the large questions of policy, the formulation of programmes and the initiation of changes lie in the hands of the military officers, those who have specialised in supply. In all our previous wars these officers were very competent to deal with the matters that came before them, for machinery then played a very small part in military affairs. But everything is changed now, and it is clear that the responsibility of devising methods of dealing with the repair of motor vehicles should have been confided to technical men. It needs a very wide experience to get out plans for repair shops to deal with thousands of vehicles a year, and this can only be done properly by men upon whom is cast the responsibility of seeing the matter through. An engineer who knows that his plans will be adjudicated upon by non-technical officers, and that neither he nor any other engineer will be present to defend them, is not likely to turn out his best work, for he has not the stimulus of a sense of responsibility. We see the result of non-technical control in the breakdown of our repair service, which was in a state of complete congestion long before the German advance precipitated matters and obliged the War Office to seek another way out of the muddle.

One would have thought that dearly bought experience would have dictated the necessity of putting the whole matter into the hands of competent engineers and following their guidance implicitly, publishing their names and calling on them to defend, if necessary, their plans. The War Office would then have been in the position of a board of directors dealing with a consulting engineer, whose reputation would be made or marred by his work. But so far no engineer has come forward to defend this scheme.

Slough was selected as the site of the works for reasons which have never been explained. It is on the Great Western Railway, but it is not particularly well situated as regards traffic to the southern ports, and it is not among a population in which labour is plentiful. Works in which 15 acres are covered with roof, as was proposed, need thousands of hands to run them, and Slough is quite unable to provide accommodation for such an increase of population. It was proposed to employ prisoners of war in large numbers, and to build barracks to receive them, but even then there must have been a large contingent of native labour and superintendence. So far it has been found very difficult to get trade

union labour to work with prisoners, and it is very doubtful if it could be done on motor repair work. In rough outdoor work, or even on agricultural work, prisoner-labour may be utilised with more or less success, but on skilled jobs it is doubtful if it is worth the trouble and expense.

The ground was by no means ideal for the erection of works. As laid out there was no proper access, and two miles of roads will need to be made for the purpose. It was only the barracks that were to be built on a main road on the south side of the line while the works are isolated on the north side. One would like to know how far engineers were consulted, and to what degree their advice was followed in the selection of the site and the lay-out of the works. It is difficult to believe that the really competent men who are to be found in the army could have devised, or even endorsed, the present scheme.

Much has happened since last spring, more indeed than in the previous four years of the war, and the time has come to consider whether the changed conditions do not demand a reconsideration of the Slough scheme with its projected expenditure of a million and a-half sterling. The disaster it was designed to avert has not happened, and the menace of it has passed away. Our workshops in France are intact, as are those of our Allies, and if we managed to get along with these during the strenuous times through which we have passed it is certain that no greater burden will now be laid upon them. There are, as we have said, many cars awaiting repairs, and our continuous advance can only be maintained by a fully equipped transport service. Unfortunately these cars cannot be dealt with at Slough. It is a big affair to cover 15 acres with buildings, and to supply these buildings with heat, artificial light, water, sanitary appliances and power, and to house the workpeople. According to our information the buildings are being laid down as a whole, and will be of little use until everything is complete. Every engineer knows the difficulty of getting material and machinery now, and it is easy to see that the efficiency of a great works might be seriously impaired for want of some essential parts. If there was at one time urgent need of such a works it is clear that the leading idea set before the designer should have been to get a part of the work done in the shortest possible time. With modern engineering factories, which are immensely long sheds, this should not be difficult to do, since they can be lengthened from time to time as material can be obtained. Gradual growth does not, certainly, lend itself to the greatest economy in the power-house, but this is of small importance in a great military difficulty, such as we have assumed last spring. If the need of such a works was urgent the system of construction adopted was entirely wrong, for it did not meet the necessities of the case.

Under the changed military conditions it becomes a question if the whole business at Slough should not be reconsidered. We would be the last to advise any slackening-off of effort to win the war. We need to crowd every man and every gun on to the front and to give the foe no respite or breathing space. But will these incompleted 15 acres of buildings assist us in the matter? If all our efforts were concentrated on, say, a fifth of them, and they were got into work in the next few weeks, they might be of advantage, but the present methods do not promise completion before the armistice is signed. Motor-car builders cannot contemplate with equanimity the concurrent cessation of Government orders for cars, and the commencement of the work of repair in this great national factory. It will take them some time to change over from their present work to building cars for private buyers, and the repair of military wagons and tractors would greatly assist in tiding over the period of reconstruction. The future of the national factories is a difficult problem. Most of them, however, have served their purpose splendidly, and if they have to be scrapped no one need complain. But the spectacle of the immense Slough works coming into operation twelve months or so after it was commenced under conditions of dire urgency, and just as it became entirely unnecessary, would be deplorable. We have said we do not know why Slough was chosen as a site, but we do certainly know that no one would choose it for commercial reasons, and that these will rule after the war.

NOTES.

Action of α Rays on Metals.

When α rays strike an insulated metallic surface in a high vacuum, the metal becomes positively charged, because the α particles carry a positive charge and because negative electrons are emitted. This particular emission, which has chiefly been studied by H. A. Bumstead, A. G. McGougan N. Campbell and V.E. Pound, has been dis, tinguished as an emission of δ rays. The ray- vary much; they may be very slow or swift; as the speed of the incident α rays decreases, the number of δ rays increases to a maximum, then to fall off rapidly, just as in the case of the ionisation of gases by α rays. Whilst, however, every gas gives its own ionisation curve, the maximum or "knee" of which is the more pronounced the lower the atomic weight of the gas, all the metals studied give practically identical ionisation curves. It was further observed that the δ ray emission was much stronger in a newly-made vacuum than when a vacuum was maintained for some time, and was reduced by heating the metal in the high vacuum of a Gaede pump, and it looked as if the δ effect with metals was not a metallic ionisation at all, but due to a film of gas on the surface of the metal. This view is supported by the most recent experiments of Mr. A. G. McGougan at Yale University, New Haven (*Physical Review*, August, 1918). The experiments are made in a brass vessel, connected with a Gaede pump, a charcoal bulb, and a McLeod gauge. On a horizontal disc, the vertical axis of which can be turned from outside, are mounted eight small discs of various metals, which by turning the disc can be brought underneath the polonium tube which emits the α rays. A second disc, similarly mounted, is interposed in the path of the rays so as to absorb them by aluminium foils of different thicknesses and thus to determine the ionisation curve. A scraping tool is mounted in a side tube and operated from outside by means of an electro-magnet. Of the metals studied lead and gold gave the most concordant results. It was found that the δ-ray emission from lead was reduced by 37 per cent. by scraping the lead surface; the new curve had exactly the shape of the old curve, though a less sharp bend; but within a day the old curve was reobtained, and after rescraping the original reduction was once more realised. Similar results were obtained with aluminium, gold, platinum, the reduction decreasing in that order; copper and silver, tried in other experiments, stood nearest lead. The arrangement was then altered so as to study the effect on a liquid surface of mercury. Instead of scraping this surface, the mercury was made to overflow the edge of the iron funnel which contained it, and the polonium was protected against contamination by the mercury vapour by a thin film of gelatine. Parallel tests were at the same time made with platinum. A slight reduction in the emission was noticed every time the mercury surface was renewed; but the full original value of the ionisation was restored almost at once. McGougan concludes from these experiments that the δ-ray effect is indeed due to the gas film on the metallic surface, and not to metallic ions. That gas film is renewed on renewing the surface, either from without, *i.e.*, from the residual gas in the vessel, or from within the metal. The "soaking-out" of the gas in the metal would be rapid in the case of mercury and more or less slow in different metals. The interior origin would also be in accord with Pound's experiments on metallic surfaces distilled in vacuo. There is some hope, therefore, that distinct metallic δ rays may be deprived of their right to existence—which would be satisfactory.

Carbide Formation and Stability.

Reviewing his recent work on carbides in a paper read before the Bunsen Gesellschaft, in April last, Professor Otto Ruff, of Breslau, pointed out that our knowledge concerning the formation and stability of the carbides and their valency relations was very defective. Qualitatively Moissan's work, to which Ruff seems to attach a higher degree of reliability than many chemists would ascribe to it, was admirable; the establishment of the quantitative relations, however, was very difficult. Owing to the retention of gases by carbon and their partial liberation at high temperatures it was hardly possible to maintain a vacuum of 3 mm. or 5 mm. of mercury in vacuum carbon furnaces which had first been filled with ordinary gases. Nitrogen, hydrogen and carbon monoxide combined with carbon above 2,000 deg. C., and the compounds were decomposed again at lower temperatures, so that a transference of carbon from spots of higher temperature to spots of lower temperature took place in the furnaces. To avoid this Ruff works in an argon atmosphere. In his lecture he referred in particular to the carbides of aluminium and of chromium as typical in certain respects. The liquid aluminium metal, he stated, dissolved little carbon. but it readily formed the solid carbide Al_4C_3, which was not fusible at atmospheric pressure, but evaporated at high temperatures, probably as such; all the carbides, however, seemed to decompose at very high temperatures. Chromium, on the other hand, dissolved carbon readily when fused, and formed fusible carbides which evaporated, but not without decomposition. One of the great difficulties was to exclude nitrogen which was bound by most carbides. In the case of aluminium, the carbide Al_4C_3, when free of nitrogen, evaporated without melting at temperatures up to 2,200 deg. C.; then it melted at a pressure of 400 mm., decomposing partly into graphite and aluminium. Ruff and his collaborators have not yet succeeded in directly analyzing the vapours of this carbide; the vapours seem to be richer in carbon at high temperatures and pressures, however, than at lower temperatures and pressures. As regards chromium, when the liquid metal was saturated with carbon, boiling was observed at 2,270 deg., and the vapour then consisted entirely of chromium. Between 2,050 deg. and 2,250 deg. the carbon percentage in the melt remained fairly constant, and the composition corresponded to the formula Cr_3C_2 as the temperature was lowered to 1,875 deg. The carbide mentioned existed side by side with graphite; there was also evidence, of the existence of the carbide Cr_5C_2. From similar experiments with many other metals it would appear that in an atmosphere of hydrogen, nitrogen or carbon monoxide, saturated with carbon, all oxides can be transformed into carbides or reduced to metals; the reactions depend upon the fusibility of the oxides or products and their capability of dissolving carbon. A great many carbides seem to exist, corresponding in their forumlæ to CH_4, C_2H_2, C_2H_4, C_2H_2, C_4H_{10}. In these carbides the heavy metals appear to have lower valencies than they possess in other compounds, and the valency sometimes decreases as the temperature is raised; thus tungsten gives the carbides WC, W_2C, W_3C. The common carbides of iron and manganese are Fe_3 and Mn_3C.

Queensland State Arsenic Mine.—At the State arsenic mine at Jibbinbar, Queensland, there are now 17 men engaged, about 20 miles from Stanthorpe, and the ore is being concentrated at the mine in readiness for treatment at the arsenic works which are to be established on the town common, a couple of miles from Stanthorpe. Work on a large scale will be commenced as soon as the plant is ready for operations.

Fuel Requirements of the United States.—We read in *Engineering and Mining Journal*, New York, that according to the United States Fuel Administration, the present fuel requirements of the United States are about as follow: The railroads must have 166,000,000 tons; 125,000,000 tons will be required for domestic lighting, heating and cooking; 57,000,000 tons went into coke last year, and a considerably greater amount will be required for this purpose this year; 14,000,000 tons or 15,000,000 tons will be required to coal ships; public utilities will consume 35,000,000 tons; 13,000,000 tons will be used by the coal mines themselves to develop power, and 5,000,000 tons was estimated to be the amount needed for producing ice during last summer. Some industrial needs are: Steel and rolling mills, 24,000,000 tons; brick, tile and clay products, 11,000,000 tons; cement manufactories, 8,000,000 tons; paper mills, 7,500,000 tons; foundries and machine shops, 7,500,000 tons; cotton mills (with southern mills using wood wherever practicable), 5,000,000 tons; meat packing and canning, 4,000,000 tons; chemical factories, 3,250,000 tons; glass makers, 3,000,000 tons; and woollen mills, flour mills and lumber mills, 2,000,000 tons each.

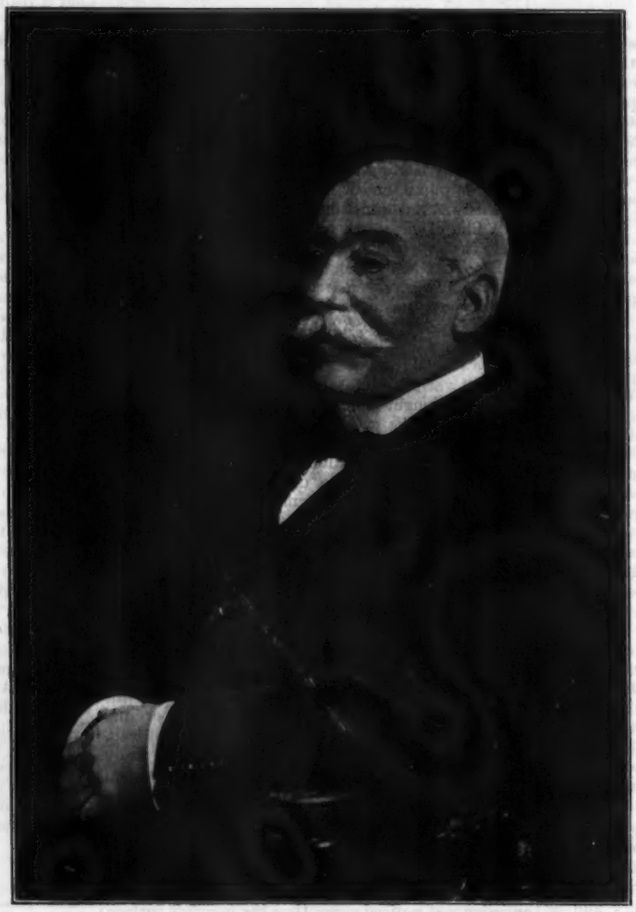
THE LATE SIR JAMES WILLIAM RESTLER, K.B.E.

We much regret to have to announce the death, which occurred suddenly on the 4th inst., at his residence, 17, Queen's Gate, S.W., of Sir James William Restler, K.B.E., the Chief Engineer to the Metropolitan Water Board. Sir James Restler was born in 1851. He was educated privately and at King's College, London; in 1867, he commenced his professional training as a pupil with Messrs. John Aird and Sons, at first in the drawing office and later at various works then in course of construction, including the St. Katharine's Docks, the Thames Defence Works at Tilbury, Gravesend, Shornmead and Cliffe Forts, acting, in the case of the latter, for about 15 months under the late General Gordon. He was also employed on the Southwark and Vauxhall works at Hampton. He subsequently obtained mechanical training in the works of Messrs. Harvey and Beck, and, later, he entered the service of the late Southwark and Vauxhall Company, under Messrs. J. Quick & Sons, who, at the time, were also engineers to the Portsmouth, Amsterdam, Staveley, Rhymney, Odessa, St. Petersburg, Beyrouth, Saratoff and other Water Companies. He thus acquired considerable experience in connection with the work of water supply to those cities.

In the year 1876, the subject of our memoir was appointed assistant engineer to the late Southwark and Vauxhall Water Company, and, in 1881, was elected to fill the newly created post of supply engineer. Two years later, in 1883, he was given the appointment of Chief Engineer to the Company, and under his direction works of considerable magnitude were carried out. Among the most noteworthy, we may mention the construction of reservoirs having a capacity of 1,750,000,000 gallons; filter beds covering an area of 23 acres; engine power capable of raising about 135,000,000 gallons of water per day; deep wells to the chalk; five tunnels under the River Thames up to 12 ft. 6 in. in diameter; and two trunk mains between Hampton and London. On behalf of his own company and of a large number of other water undertakings, he frequently gave technical evidence before Royal Commissions and at Parliamentary enquiries and proceedings, and acted also as adviser to other companies and local authorities with reference to the purchase or the sale of their undertakings, or with regard to the best course to follow in order to obtain additional sources of supply.

When the Metropolitan Water Board took over the London water undertakings, Sir James had in course of execution a scheme comprising two storage reservoirs having a capacity of 12,000,000,000 gallons, combined with a pumping station and contingent works capable of supplying 100,000,000 gallons per 24 hours into these reservoirs. In connection with this scheme, two lines of 48-in. mains were laid from Walton in a tunnel driven under the Thames to supply water to the Hampton filter beds. These works were completed and placed in the service in 1911.

Sir James designed the Honor Oak Reservoir which was opened on May 5, 1909 (see ENGINEERING, Vol. lxxxvii, page 633). This covers 14¼ acres; the greatest depth of water is 34 ft., and the height above O.D. is 144 ft. It has a capacity of 56,300,000 gallons, the water coming from Hampton, a distance of 17 miles, by a 42-in. main, while there is also a supply from the adjoining well.



Elliott and Fry, Photographers.

SIR JAMES WILLIAM RESTLER, K.B.E.

Sir James was appointed Chief Engineer to the Metropolitan Water Board on November 27, 1914, in succession to the late Mr. W. B. Bryan, and subsequently to this he had under construction a storage reservoir in the Thames Valley, to contain 7,000,000,000 gallons, the work on which had to be suspended through difficulties due to the war. In the year 1915, the Water Board obtained an Act for the carrying out of a considerable amount of new work, Sir James being the engineering witness for the Board during the passage of the Bill through both Houses. Further, and in addition to his ordinary duty, he prepared in great detail a scheme of very extensive character for safeguarding the Board's supply for a considerable number of years, a scheme which, but for the war, would in all probability have received the necessary sanction and the works in connection therewith have been now in course of construction.

In the early stages of the war, the Director of the Works at the Admiralty applied to the Board for the services and the advice of Sir James with regard to the water supply to a large number of Naval establishments. Some of the works in this conjunction have been satisfactorily completed, whilst others are still in hand. Upon the formation of the Metropolitan Munitions Committee, in June, 1915, Sir James was elected Vice-Chairman of the Board of Management; later, upon the resignation of Mr. Hall Blyth, he was appointed Chairman of the Committee, and the great engineering experience which he was able to bring to bear upon the particular work entrusted to this Committee was of inestimable value. In order further to illustrate Sir James' numerous activities we may add that in July, 1917, the Home Secretary appointed him Chairman of the Fire Brigades Co-ordination Committee, a Committee which was instituted to formulate a scheme for the co-ordination of the measures to be taken by the London Fire Brigade and the surrounding Fire Brigades for dealing with fires caused by air raids. Sir James met with complete success in this difficult task and contributed very largely in the actual work for the protection of the Metropolis against air raids; on every occasion of a raid he invariably proceeded to the Headquarters of the London Fire Brigade and to any of the large fires that occurred. We may mention, in this latter connection, that Sir James was one of the first members of a voluntary Fire Brigade in London, joining as early as 1870, and since then he had remained in touch with the London Fire Brigade and was a personal friend of all the Chief Officers. Further evidence of his interest in this sphere is afforded by the fact that he was a member of the Central Council of the National Fire Brigades Union and Chairman of the Surrey District of that body. He also organised a very efficient fire brigade at the Board's largest group of pumping stations at Hampton.

Sir James was a Member of Council of the Institution of Mechanical Engineers and had been elected a Member of Council of the Institution of Civil Engineers for the current session, which commenced on Tuesday last. The honour of a Knight

Commandership of the Order of the British Empire was conferred upon him by His Majesty the King in recognition of the valuable services he had rendered to the nation in connection with the war. He was Chairman of the Rickmansworth and Uxbridge Valley and also of the St. Albans Water Works Companies. Though a strict disciplinarian, Sir James was a man of charming manners and courteous to every one; his decease will be deeply regretted by a wide circle of friends. One of his strongest features was his love of mastering most thoroughly the details of everything he undertook.

INDUSTRIAL NOTES.

THE War Cabinet recently set up a Cabinet Committee to deal with post-war priority questions. This committee consists of General Smuts, the President of the Board of Trade, the Minister of Labour, the Minister of Shipping, the Minister of Munitions, and the Minister of Reconstruction; the Secretary is Colonel Byrne, C.M.G., 11, Pall Mall, London, S.W.

A Standing Council on Post-War Priority has been appointed to assist the Cabinet Committee and is now at work. The council has already had before it a survey of the existing stocks of the more important raw materials, and is giving urgent consideration to the question of releasing such materials from any form of control at the earliest possible moment.

It is the intention of the council to consult the trade bodies concerned with regard to any matters affecting the industries they represent, and, by taking them into their confidence, to make the utmost possible use of their organisations in any allocation of materials which may be found to be necessary.

The personnel of the council is not yet complete, but it is felt that as it is already in session a public announcement on the subject is called for.

Communications should be addressed, for the time being, to the Joint Secretaries, Standing Council on Post-War Priority, 2, Queen Anne's Gate Buildings, Westminster, S.W.1.

Mr. W. L. Hichens, chairman of Messrs. Cammell Laird and Co., Limited, in the course of his lecture delivered in London, on October 30, under the auspices of the Industrial Reconstruction Council, stated that we had become so accustomed to Government control in the everyday affairs of life during the war, we were so inured to the establishment of new departments and new controllers, that the invasion of what were formerly regarded as the rights of the individual no longer checked or alarmed us. Proposals had been made to nationalise the railways, all roads and water transport services, the coal mines, private armament firms and shipbuilding firms; it had been proposed that the State should establish super-power stations for the supply of cheap electric current; that it should finance or take over the key industries, &c., Some of the reasons why, he thought, the Government should keep outside the arena of commerce and industry were the following:—

In the first place, the Government had already more than enough to do without annexing a vast new sphere of activity. Even before the war the business of Parliament was hopelessly congested, and no one would contend that in the turmoil and confusion of the next few years its duties would be lightened. The second objection was that State trading tended to create international complications and increased the risk of war. The international problems of the next generation would be in a great measure economic; the importance to a country of commerce and industry was likely to be more fully realised than ever before, and their promotion would be a primary object with all Governments. Each Government, therefore, should be in a position to consider these international problems from as broad and detached a point of view as possible. A third objection was that State trading on an extensive scale created a large army of civil service voters. A fourth objection was that a public office could not be run on business lines, the conditions of the public service and private undertakings differed entirely and demanded a different form of organisation. A fifth objection was that State trading eliminated competition, and introduced a rigid uniformity of administration which resulted in stagnation. The State, further, would not dare to take the risks that private enterprise did and must if it was to be successful. As a final objection, Mr. Hichens said that by itself entering the arena of trade, the State lost the detachment and impartiality which were expected from the ultimate controlling authority.

On the other hand, the primary function of the Government in relation to industry was to determine the conditions under which industry shall be conducted by private enterprise and to see that those conditions were carried out. If it were itself the largest employer of labour it would disqualify itself as the final court of appeal. The other task of the Government was to promote industrial research, to develop the consular services, to take in hand the thorny problem of the support of the key industries and the still more controversial problem of Protection *versus* Free Trade. In this category, Mr. Hichens also included the elimination or prevention of wasteful competition.

The United States Steel Corporation, says *Engineering and Mining Journal*, New York, has adopted the eight-hour basic day. This change in its policy became operative on October 1, and affects the greater part of the 275,000 men engaged in the corporation's mills, mines, furnaces and transportation organisations. The eight-hour day will now be the basis for calculating wages and working periods for these employees, and it is expected that increases in wages in some departments will result. Announcement of the new order was made on September 24 by Judge Elbert H. Gary, chairman of the board. The open-shop plan heretofore in force throughout the works will be continued.

Dealing with this same question, *The Iron Age*, New York, says that the working out of a plan for the application of the eight-hour measuring rule to the iron and steel works day is proving no easy task. Two features of the Steel Corporation's programme have been announced—first, that for work on Sundays and holidays the usual rate will prevail except on hours over eight, for which time and a-half will be paid; secondly, that overtime payment will apply to tonnage men and piece workers, the same as to workers by the day.

It is unfortunate, adds our contemporary, that such a considerable part of the daily press so far fails to understand what "the eight-hour basic day" means in the steel industry as to cause it to infer that its recent adoption is a step towards—if not an actual adoption of—an eight-hour work day, or in other words, the establishment of a three-shift system in cases where two shifts have hitherto been the rule. Such a change would, of course, be suicidal and would greatly decrease the output of pig-iron and steel, for the 50 per cent. increase in the number of men required for the jobs could not be secured. Instead of the adoption of this system of payment being a step in that direction, it is a measure of protection against such a trend. It puts a premium upon the hours it is vital the men should work in order to maintain production.

The system has one menace to the war-time programme—that it may encourage men to "lay-off" more frequently, for the 50 per cent. bonus is for the last four or the last two hours the man works on any given day. Perhaps measures can be taken against men absenting themselves more frequently than hitherto. The fact should be recognised at large, however, as it is in the steel industry, that the average steel mill worker, given a certain hourly rate of pay, prefers to work the long hours.

The prices, in marks, of coal per ton, in the first quarters of 1914 and 1918, and on September 1, 1918, and miners' wages in Germany, are shown by the following table appearing in *Wirtschaftsdienst* (September 6):

I.—Coal Prices.	First Quarter.		Increase Per Cent.	Sept. 1 1918.
	1914.	1918.		
Bituminous rough coal ..	11·25	24·30	116	26·85
Rough gas coal	12·00	24·90	103½	27·45
Forge coal nuts	15·50	29·40	89½	31·05
Household nuts	13·75	27·90	101½	30·45
Anthracite nuts	21·75	37·20	71	39·75
Blast-furnace coke (1st quality)	17·00	33·60	99	37·20
Foundry coke	17·50	34·20	97½	37·80
Crushed coke	20·00	37·20	86	41·40
Briquettes (1st quality)..	13·75	28·60	103½	31·15

II.—Miner's Wages.	1914.	1918.	Increase Per Cent
1. Per head of an entire gang ..	5·22	9·46	80·3
2. Miner working underground ..	6·49	12·16	99·7
3. Surface worker	4·37	7·68	70·7

The South German textile industry, in co-operation with the Wurttemberg Government, the Technical High School in Stuttgart, and the Royal Technical College for the Textile Industry in Reutlingen, has recently founded a German Research Institute for Textiles, says the *Weser Zeitung* (September 28). The new Institute will take over and extend the labours of the research office which has existed for some years in Reutlingen. The Institute is already spinning, weaving, and manufacturing all kinds of papers and cellulose, new fibres, *e.g.*, nettles, cellulose and cotton mixtures, pine needle wool, bulrush fibre, broom fibre and artificial materials. It will also inquire into labour conditions.

As a sequel to the conference held in London in June last, at which it was decided to conduct throughout the country a campaign for the prevention of industrial accidents, an influential organisation has been formed comprising representatives of the Admiralty, Board of Trade, Home Office, Local Government Board, and the Ministry of Labour, and of leaders of industry and labour. The title of the new body is the British Industrial "Safety First" Association. Its first meeting was held at the Mansion House on October 31, when Lord Leverhulme occupied the chair, and was elected president.

The policy of the association is the formation in every industry of a "Safety First" Committee comprising representatives of employers and employees and of committees in the leading firms to investigate the causes of accidents peculiar to the particular industry, and to discover and apply effective measures and safeguards to prevent the recurrence of similar accidents. As numerous avoidable accidents are due to carelessness and thoughtlessness on the part of the employees, a comprehensive educational campaign is proposed to be conducted from headquarters, and members of the association will receive regular supplies of posters and literature designed to point out the known causes of avoidable injuries.

It is contended that the maximum success in the alleviation of the suffering and sorrow which industrial accidents entail, as well as the saving, and the utilisation for better purposes, of the huge sums which would otherwise be paid as compensation, or would represent losses of wages, would be achieved at the minimum cost if industry and labour combined to co-operate with the association in the prosecution of the industrial "Safety First" campaign.

Applications for membership of the British Industrial "Safety First" Association should be addressed to the Hon. Secretary (*pro tem*), Mr. H. E. Blain, at the temporary offices of the association, 31, Westminster Broadway, London, S.W. 1.

Writing in *The Empire Review* for the current month, Sir Vincent Caillard deals with the problem of reconstruction after the war and states that there has been in this country a growing tendency for the representation of the constituencies to fall into the hands of men, highly gifted no doubt, but without that direct knowledge of industrial and commercial conditions which, always desirable, has now become of vital necessity when the nation depends on those great interests for its restoration. It is not only necessary that there should be more business men in Parliament; it is even more essential that they should be there as men of business. Apart from the interests of industry and commerce themselves, the interests of the nation demand the service of men with first-hand knowledge applying it without regard to any secondary considerations.

From this conviction, which has burned itself into the minds of business men, has sprung the British Commonwealth Union. To quote the words of one of its founders, it has for one of its main objects, "that on national questions relating to industry and commerce as great and as varied support as possible should be received in Parliament irrespective of party and amongst all interests concerned." But it goes further still in seeking to co-ordinate that support. While the Union perceives that without adequate representation in Parliament the organisation of business must lose much of its value, such representation to be truly effectual must reflect, not sectional, but general interests and opinions. With such aims before it, it follows that the Union opens its doors to all of British nationality, irrespective of political creed, who share its views.

The outlines of the Union's general programme to be filled in by co-ordinate consultation are as follow: The attainment of a just and lasting peace; preferential relations inside the Empire and adhesion to the conclusions of the Paris Conference; complete power of tariff bargaining; the establishment and maintenance of essential key industries under wholly British control; restriction of imports of manufactured articles from enemy countries for such a period as may be desirable; strict naturalisation laws; the encouragement of scientific research by State assistance direct or indirect; an efficient diplomatic and consular service; the development of home resources, including agriculture, in every legitimate way, with specific measures to ensure that loans raised in the United Kingdom for industrial purposes should be conditional on the use of British manufactures. The industrial policy of the Union is conceived in a similarly broad spirit. In linking up wages with housing, health and education, and making all four dependent on industrial prosperity, which is itself dependent on increased production, the Union takes

up a statesmanlike position in which it will have the support of the more reflective elements of labour.

Specifically renouncing any desire to invade the domestic activities of organisations connected with industry and commerce, the Union purposes to be their complement, not their rival, co-ordinating where necessary their interests, and acting as the striking force when legislation threatens them or becomes desirable for their promotion.

A large and influential deputation of members of both Houses of Parliament waited last Tuesday upon the Ministers of Pensions and of Labour to urge upon them the importance of taking steps to secure the employment of discharged disabled men by means of a general appeal to employers for this purpose. The deputation was introduced by Mr. T. E. Wing, M.P., who drew attention to the proposals in the scheme promoted by Mr. Rothband, of Manchester. In reply, Mr. Roberts stated that the employment of disabled men was under the anxious consideration both of the Minister of Pensions and himself, and that they were in agreement with the general principle of an appeal to the trade and industry of the country for the purpose suggested. Sir A. G. Boscawen, on behalf of Mr. Hodge, Minister of Pensions (who was unfortunately prevented by illness from being present), expressed his cordial agreement and indicated that the operation of any scheme for the purpose could be most effectively carried out through the machinery of the departments concerned. It was understood, accordingly, that the Ministries of Pensions and of Labour would proceed to concert the details of the scheme without delay.

FEDERATION OF BRITISH INDUSTRIES.

The annual general meeting of the Federation of British Industries was held last week at the Connaught Rooms, Great Queen-street. The proceedings commenced on Tuesday, when a special general meeting was held, when the new constitution was formally approved.

On Wednesday, the retiring president, Sir Richard Vassar Smith delivered his presidential address. He remarked that the federation had now commenced the third year of its existence and continued to grow and thrive. It had nearly doubled its membership and considerably more than doubled its strength. A year ago it represented 581 members and 78 trade associations; to-day the membership was 951, in which number 164 trade associations were included. This was a remarkable result and a striking tribute to the founder of the federation, who realised the need for a national organisation of this character. He wished to congratulate the committee which had drawn up their new constitution. If an organisation of that size was to avoid stagnation it was essential to provide it with an elastic constitution, so that each section might make its voice duly heard in the governing body. Such a constitution they now had. A distinctive feature of the past year had been the organisation of the Parliamentary side of their work. Under the chairmanship of Sir Rowland Barran, the committee of this group had met with considerable success. Their other activities were set forth in the report, and no one could doubt that the federation was justifying its existence by practical results. It was also evident that their activities were founded on sound ideals. In the past it had been the object of unjustifiable criticism and suspicion, but these were fast dying out, and he hoped that the discussions which were to follow would end them altogether. The president went on to refer to the various questions which were to be discussed, pointing out that the most urgent and difficult was the tariff question. They were now within sight of being able to present to the Government a national policy which would meet the requirements and safeguard the interests of every trade. Another vital matter of State policy was taxation. The resolution which would be proposed on this subject sought to define the principles which should guide the Government in apportioning taxation. Other important subjects they were to consider were labour, education, housing and the organisation of industry through trade associations. It would add enormously to the strength of the federation and to British industry generally if their huge membership would definitely adopt the policy of buying each other's products in preference to foreign goods. Finally, it would be impossible to direct the process of reconstruction effectively without the co-operation of industry.

Sir Richard Vassar Smith then proposed that Sir Vincent Caillard should be the president for the coming year. This was seconded by Mr. Dudley Docker and unanimously agreed to. The following gentlemen were appointed vice-presidents: Lord Abercorway, Sir Rowland Barran, M.P., Sir A. Herbert Dixon, Bart., Sir Algernon F. Firth, Bart., Sir Robert A. Hadfield, Bart., Mr. E. Manville, Sir H. R. Rowell, K.B.E., and Mr. W. P. Rylands. Sir Vincent Caillard, Mr. F. Dudley Docker, C.B., Sir Algernon F. Firth, Bart., Sir Robert A. Hadfield, Bart., and Sir Richard Vassar Smith were appointed trustees. Messrs. W. B. Peat and Co. were appointed auditors.

Sir Algernon Firth proposed the first resolution, impressing on the Government and country the necessity of maintaining the principle of private ownership of capital and encouraging the free flow of capital into industry and of preserving and encouraging that spirit of individual enterprise and initiative which was the vital principle of national life. In the course of a lengthy address he pointed out that when the war commenced there were only 345,000 holders of British Government securities; now there were some 16,750,000, while there were 11,000,000 accounts in the Post Office Savings Bank and over 2,000,000 in the Trustee Savings Bank. After the war they must secure that these savings must be encouraged to flow into productive industry. If the incentive to individual effort was removed and replaced by any system of governmental or communal control the death knell of the prosperity of their industries would be sounded. The interests of the community were best served by the fullest opportunity being afforded for the free play of individual talent. They wanted individual effort encouraged, security for their business and not meddlesome interference, and that support of their workers which they could secure if left alone. Mr. H. R. Armitage seconded the resolution, and it was carried unanimously.

Mr. Dudley Docker moved a resolution emphasising the supreme importance of British industry and urging upon the Government the necessity of recognising the importance of industrial interests and of consulting the representatives of employers no less than of employed. But industry must recognise that it owes a duty to the community, and in pursuance of this duty the federation would endeavour by co-operative and other means to raise production to the highest level both of quantity and quality, to reduce expenses of distribution and the cost of goods to the consumer and to ensure the maintenance of industrial peace and the enjoyment by all those engaged in industry of the fullest share practicable in the creation and distribution of wealth. It was for manufacturers to see that the industrial system did not lead to results which were not socially justifiable. The resolution was seconded by Mr. P. H. Lockhart and carried unanimously.

Sir Vincent Caillard moved a resolution on the subject of national economic policy, remarking that they had reached the point when they could look at the subject free from old prejudices and controversies. Before the war, Protectionists and Free Traders seemed to live in worlds of different dimensions, but now they could see that different industries had different interests. Their object was to frame a policy that should safeguard the requirements of all those interests whether by way of protective duties, maintenance of free import, subsidy transport facilities or otherwise, and thus enable each industry to attain its maximum productions. The whole strength of the country and the whole well being of all classes and of labour especially rested on production. The resolution also included declarations in favour of preferential treatment for the Empire and our Allies, and urged the Government to set about the preparation of provisional schemes immediately in order to apply a practical test to the problems involved. It was seconded by Mr. Muspratt and carried unanimously.

A resolution was moved by Mr. T. Biggart urging the Government so to regulate and apportion taxation as to encourage the flow of capital to industry and increased production; the provision of adequate reserves to meet the cost of renewals and extensions and the maintenance by manufacturers of adequate stocks. The resolution was seconded by Sir William B. Peat and carried unanimously.

On Thursday morning the proceedings were commenced by Mr. F. W. Gilbertson moving a resolution which affirmed the importance of improving education, both primary, secondary, and adult, w th a view to, enriching the mental life of the nation and developing individual character and initiative and enabling every citizen to take his proper place in the activities of the community. Bailie John King, of Glasgow, moved a resolution on "housing," urging the importance of securing in all housing schemes the greatest amenity in regard to lay-out and design, of avoiding as far as possible the segregation of classes, of allowing for the provision of adequate facilities for recreation and education, and providing such accommodation in each house as would enable the inhabitants to live in decency and comfort and to turn their leisure to profitable account.

Sir Robert Hadfield, Bart., moved a resolution dealing with technical education and inviting the co-operation of the Government, organised labour and educational authorities, with a view to improving technical and higher commercial education, to promoting the employment by manufacturers of students who had taken advantage of the courses provided and to securing the introduction into industry of an adequate and regular supply of suitably-trained personnel.

Mr. Frank Moore moved a resolution affirming that the federation viewed with grave concern the recurring instances of industrial unrest and recorded its approval of the general principles underlying the first report of the Whitley Committee; and inviting the group and sub-group committees to consider how far these principles could be applied to their industries.

Mr. Max Muspratt moved that with a view to consolidating the industries of the country and reducing the speculative fluctuation in prices, members were recommended as far as possible to draw their requirements of manufactured products from members of the federation.

Mr. H. R. Armitage moved a resolution impressing upon manufacturers the great advantage to be derived from co-operation and the organisation of industry through trade associations.

The last resolution was one approving the general lines of the policy of the Minister of Reconstruction in forming joint committees of employers and workpeople to advise the Government on reconstruction questions, but emphasising the necessity of adapting this policy to suit the conditions of the different trades.

Sir Vincent Caillard, presiding at the luncheon, remarked that manufacturers did not always see eye to eye with the Government. They recognised the great and sterling qualities of those gentlemen and the tact and courtesy which they invariably displayed. The present gathering would afford those gentlemen an exceptional opportunity of saying anything they wished to say to British industrialists to a great assembly which represented pretty well the whole industrial energies of the kingdom. They were very nearly a thousand in membership; they would probably be a thousand in the course of a few weeks; they represented through direct membership of firms and associations something like 16,000 manufacturing firms in this country and an aggregate of 4,000,000,000*l.* of capital. They were not out for selfish ends, but for the general good of the country. There would be in the consideration of the great subjects which they would have to face no poison of selfishness. They would subordinate any supposed individual or class interest to the corporate needs and the national good. They would be glad to hear from their visitors the Government's intentions with regard to the control of industry which they recognised as a necessity for some period after the war, but which they hoped would be relaxed as quickly as possible in order that industry may have the free play which was its life blood. They would like to hear something about the plans for demobilisation and particularly those for the employment of the soldiers and sailors. They would also like to hear something about reconstruction—not the appointment of committees, but decisions taken and results attained. They would also like to hear something as to the future economic policy of the country.

Sir Auckland Geddes, who was the first to respond to the toast of "The Guests," said: Our reconstruction must have the effect of making every family in the State feel that its position and health and well-being was of real interest to the State. There was nothing more appalling than the condition of health of the people.

Dr. Addison dealt with the subject of demobilisation, and said the first business of the Government would be, as quickly as possible, to re-establish the great basic industries of the country. They must expedite the restoration of those industries as much as possible. The great problem was the supply of raw material and they had already arranged with the Shipping Controller a programme of shipping, directed to bring over as quickly as possible the raw material which the industries required. The Ministry of Shipping was sanguine as to being able to provide at quite short notice the necessary tonnage. The Government would cease control as soon as they could safely do so, and they wanted the industries then to take over the control that might be necessary. The resolution passed by the federation on reconstruction exactly expressed his own policy. He formally accepted the federation's offer of co-operation.

Mr. Hewins, Under Secretary for the Colonies, dealt with the economic policy of the Government. Whether Protection or Free Trade were good things in the abstract he did not know; the question was whether as regards any particular trade or industry tariffs should be set up. It was a question of the particular requirements of the particular trades. In the Paris resolutions and the resolutions of the Imperial War Conference in 1917, the Government had set out its intentions. What had to be done now were matters of detail. The reasons why the Government had not made a statement as to economic policy was not that the Government had not a policy. It was carrying out that policy effectively, but they could not deal with these questions as a set of philosophers.

Mr. G. J. Wardle, Parliamentary Secretary of the Board of Trade, said he hoped the time was not far distant when instead of having separate congresses of employers and workers they might have joint conferences. Everything must be done to bring employers and employed together, and he was glad to see that many of the resolutions passed by the federation emphasised this. They must have self-government of industries, but not with labour shut out.

The Industrial Reconstruction Council.—This body, whose offices are at 2 and 4, Tudor-street, E.C. 4, inform us that they have joined forces with the Reconstruction Society. The fourth lecture of the series arranged by the Industrial Reconstruction Council will be held in the Saddlers' Hall, Cheapside, E.C. 2, on Wednesday, the 13th inst. The chair will be taken at 4.30 by the Right Hon. Lord Burnham, C.H., and a lecture entitled "A Retrospect from 1970" will be delivered by Sir Arthur Steel-Maitland, Bart., M.P., Parliamentary Secretary, Foreign Office and Board of Trade (Department of Overseas Trade). Applications for tickets should be made well in advance to the Secretary, at above address.

Exhibition of Enemy Aircraft.—The Royal Air Force Exhibition of Enemy Aircraft will be opened at the Royal Agricultural Hall, Islington, N., by the Right Hon. the Secretary of State for the Royal Air Force (Lord Weir), at 3 p.m. on Friday, November 15. The opening will be by invitation only, and the public will be admitted at 5 o'clock. The exhibition will be open to the public from 10 a..m to 8 p.m. on Mondays, Wednesdays, Thursdays and Saturdays until January 18. Admission, 1*s.* After November 15, passes will be issued to manufacturers for the benefit of designers, heads of departments, charge hands, &c., as hitherto, on application in writing by the employers to C.T.D., Ap.D. (L.), Central House, Kingsway. These passes, however, will only be available for admission on Tuesdays and Fridays.

"THE MERCHANT SHIPBUILDING PROBLEM."

To the Editor of Engineering.

Sir,—Your able editorial of the 1st inst., serves admirably to draw public attention to the fact that to have won the war, but to have lost our pre-eminence in the world's shipbuilding industry, yet leaves us with something approaching a national disaster. You must, however, agree, upon consideration, that your suggestions go quite a small way towards meeting the revolutionary changes which are essential if we hope to remedy the present state of affairs. It is no use thinking this change can be brought about by rebuking some sections of the workpeople for inability to appreciate that they should work a lot harder, or by chiding a few shipyard officials for their conservatism. The capable organiser, when confronted with a brick wall of the sort indicated, always goes round it in preference to knocking up against it, and after all it is quite unlikely that the newly fledged American shipyard man works any harder or longer than his British prototype. We must recognise that the standard condition for many a day to come is that if a workman is contented he will work only moderately hard. If he is not contented, he will work less hard or not at all, and if his work is laborious or fatiguing he is more likely to be in the latter company than the former.

It is not often appreciated sufficiently that the design of structural detail and methods of production in our shipyards to-day are very little different from those instituted forty years ago by our early iron shipbuilders. This may speak very highly of the ability and foresight of those pioneers, but when one considers the enormous advances which have taken place in other modern industries, such as marine engineering, ordnance manufacture and many more, during the same period, it is possible that after all there may not be very much cause for self-satisfaction.

It is true that in present-day structural shipbuilding, the amount of machine tools and mechanical equipment employed is considerably less in proportion to the labour wages spent than any similar industry in the country, whilst the conditions under which many of the people work are equally out of date. Perhaps the worst sting of your article lies in the statement that the wonderful shipbuilding achievements being made by the United States are mostly through organisations directed by men and operated by workpeople who as recently as two years ago, were totally ignorant of the practice of shipbuilding.

It is a pity, however, that your article did not enlarge upon the chief lesson to be learned therefrom. These men have been brought up and trained in an atmosphere impregnated with ideas of production and repetition processes very different from anything which has been considered necessary in this country. Methods which dominate the manufacture of the domestic sewing machine, or the democratic automobile, for examples, have had an enormous educating influence upon most industrial processes in America and have very largely made their influence felt in many branches of industry in this country. It is fully realised by many sections of our engineering community that America's greatness lies, not in excellence of design, but in scientific labour-saving production, and it is undoubtedly a fact that their experience in this direction is being largely used to-day in their shipbuilding processes. In other words, it has been proved that scientific direction and organisation is more potent than the practical skill of the individual workman.

Standardisation, as understood by America, is a thing totally apart from what is called standardisation by our shipbuilders. No standard ship yet built will stand the test of having an assembled piece of structure removed from it, with the certainty of it fitting a similar ship built to the same dimensions and even made from the same moulds and templates, for the reason that systems of limits, while common in many other branches of industry, are almost unknown in shipbuilding practice, simply because there has never before been any need to use them.

How this affects matters may be seen when it is remembered that the speed of building ships depends primarily upon:—

(*a*) The number of slipways available in the country.

(*b*) The amount of structural labour which has to be done upon the slipway.

(*c*) The accessibility of the structure and the number of men which can conveniently be employed on same.

(*d*) The number of days of the year which permit of work in positions exposed to weather.

(*e*) The number of workpeople it is possible to crowd into the vicinity of shipyards.

All these factors are manifestly controlled by the amount of work which is done upon the material before it arrives at the slipway at all, and therein lies the most promising way to the big improvement desired. Our inland manufacturing towns contain many thousands of workpeople skilled to a high degree in repetition methods and accustomed to working to dimensions of considerable accuracy by the aid of jigs and templates, to an extent undreamed of by the average shipbuilder. Their services are partly free now, but certainly immediately the war finishes they will be available for ship construction, which of all national requirements is likely to be the most urgent. The few operations they do not know can be quickly taught them, and thoughtful lay-out and organisation will reduce transport difficulties to an inappreciable minimum.

The present organised system of "fabrication" on the premises of certain steel works, &c., is of comparatively small assistance, because it employs labour in a direction that has very little effect upon the actual bottle-neck of the operations of structurally finishing a ship.

The crucial difficulty in the way of adopting my suggestion is that before this army of workpeople can materially contribute their assistance, a certain amount of revision must take place in methods in our shipyards and some amount of alteration of design would be desirable to make the best use of it. Whether our shipbuilding establishments will avail themselves of such opportunities is doubtful, but one thing is not uncertain, viz., that America will continue to use such methods to her advantage and will largely develop them, and if we do not follow suit, our national position will be worse than it is now.

Yorus truly,

T. G. John, M.I.N.A., A.M.Inst.C.E., A.F.Aero.Soc.

"Ferndale," Manor-road, Coventry,
November 4, 1918.

"THE INACCURACY OF THE GAS METER."

To the Editor of Engineering.

Sir,—May I offer a brief explanation in reference to a remark that occurs in your article of October 25, page 468, reviewing my paper on "Unaccounted-for Gas." The passage is as follows: "The company correct their make to a standard—leaving their consumption uncorrected; so calculated on the whole year, these corrections give a figure of unaccounted-for gas annually which averages ¾ per cent. (on the make) too much. In his charts exemplifying unaccounted-for gas, during the last ten years Mr. Parkinson deducted this ¾ per cent. from the figures supplied to him. The whole correction is obviously crude."

The above would imply that the ¾ per cent. was the correction actually used, but that is not so, for the chart figures were corrected quarterly according to actual mean temperatures and pressures. The ¾ per cent. and also the other figures quoted in your review may be rightly described as crude; they are only given for the sake of example. The actual differences made by the correction annually, vary in ten years from 0·1 per cent. to 1·3 per cent., and between these extremes lies the mean 0·7 per cent. or, crudely, ¾ per cent. Quarterly the variation is far greater according to the seasons of the year, and the extreme variations in ten years are 3·69 in the winter and minus 2·32 in the summer.

I am, Sir, yours faithfully,

B. R. Parkinson.

Gas Light and Coke Company, Goswell-road, E.C.

"COAL SAVING BY SCIENTIFIC CONTROL OF STEAM BOILER PLANT."

To the Editor of Engineering.

Sir,—I have read with much interest the various letters from Mr. Anderson, and fully appreciate his attitude towards your correspondent "Get a Move On." I cannot, however, allow two paragraphs which appear in his letter of Friday last, to go by without comment.

(*a*) I agree with Mr. Anderson that water-tube boilers are largely used at power stations, but probably the smaller space taken is a factor in their favour, as I am quite satisfied that a Lancashire boiler seated and fitted out on modern lines, properly stoked and operated by the same draught, will give as high an efficiency as a water-tube boiler. I have in mind several installations of Lancashire boilers in Yorkshire, where the overall efficiency exceeds 80 per cent., in one case 85 per cent. is attained, and it is knowing the possibilities with this type of boiler which makes me so persistent in advocating more scientific methods of working it.

(*b*) My second objection is to Mr. Anderson's comment on "Boiler Firemen." I have been amongst them directly and indirectly for years, and given to some of their societies in Lancashire and Yorkshire over a dozen lectures on handling boilers and similar subjects, and have always found them most willing to learn and to adopt any suggestions for betterment, in fact, taking them as I have found them, they are a class of good fellows, and the world would be better with more like them. Once a stoker sees he can work on better lines and help his employer more, he will do so, but the majority of them to-day are comparatively new men, and have not had the opportunities for learning how to do this; they really then require at present sympathy rather than blame.

Yours faithfully,

W. H. Casmey.

Milnthorpe, Wakefield, November 5, 1918.

WOMEN IN THE DRAWING OFFICE.

To the Editor of Engineering.

Sir,—In your issue of October 18 appears an account of the National Conference of Women, and in the account occurs a remark from a Mr. Ben. Morgan, who spoke as one having authority (from the Ministry of Munitions), and gave the benefit of his experience to the assembled ladies. The remark is to the effect that "women are specially suitable for such *semi-skilled* operations as tracing, and *draughting*." It is possible that the rest of Mr. Morgan's speech was accurate and reliable, and as the apparent object of the conference was to indicate to the ladies the departments and processes of industry which held out the best prospects for their employment, I am sure Mr. Morgan will not object to a correction.

Therefore, ladies, be not misled. You are as welcome to the drawing office as you have been to the shops. Many of you have been there for years—tracing—and you have done the work moderately well; I can say no more. You will be employed willingly enough as draughtswomen when you are capable of supplanting draughtsmen, and if you organise yourselves properly you will perhaps earn as much money. Do not, however, let this golden dream of Mr. Morgan deceive you into believing that you can command the princely salaries paid to draughtsmen in the short space of time that "semi-skilled" would seem to promise. Rather, make up your minds for years of hard preliminary work. For days spent in the shops and nights in the technical classes. Look up your mathematics, your mechanics, your geometry. Be sure that you will have to know something of most engineering processes, from pattern-making to freightage, and a variety of matters there is no space to enumerate. And then, after having thoroughly ascertained what you will let yourselves in for, ask yourselves whether there is not some equally well-paid, semi-skilled job among the Ministry officials that would be more to your purpose.

And may I deferentially suggest, Sir, that the next time Mr. Morgan undertakes to give advice he gets his particulars of drawing-office work from No. 8, Victoria-street, S.W. 1, which is the Head Office of the Association of Engineering and Shipbuilding Draughtsmen, where fully-skilled information may be obtained free, gratis, and for nothing.

Yours faithfully,

Ernest H. Walker
(Chairman, National Executive).

61, Claverton-street, S.W. 1, November 4, 1918.

Fleet Builders.—Messrs. J. Readhead and Sons, West Docks, South Shields, have just launched the Trevanna, the seventy-fourth vessel that they have built for Messrs. Edward Hain and Son, St. Ives, Cornwall. She is the last of six they were commissioned to build for the firm before the war, and is one of the biggest types of merchant vessels. Mr. James Readhead, the managing director of the builders, who was present at the launch, has witnessed the launching of all the 74 vessels that comprise the "Tre" fleet.

New Fabricated Ship.—Sir W. G. Armstrong, Whitworth and Co., Limited, have just delivered from their Walker shipyard their first fabricated ship, designed by themselves. She is constructed on the Isherwood system of longitudinal framing, and has a carrying capacity of 10,000 tons. The keel was laid on March 11 this year, the launch taking place on September 5. The total time from keel laid to handing over was 31 weeks 5 days. Circumstances beyond the control of the builders interfered with the work of completion, or the vessel would have been finished a month earlier. The experiment in fabrication was, however, very satisfactory, and promises well for despatch in the building of the rest of the ships of the series at this yard.

Shock in Hydraulic Systems.—Mr. Alfred Towler, M.I.Mech.E., of the Leeds Engineering and Hydraulic Company, Limited, read recently, before the Leeds Association of Engineers, a paper in which he stated that shock in hydraulic systems could be ameliorated by interposing some form of cushion or relief at the zone of maximum intensity. The term "momentum valve," he added, was a misnomer; it was not a valve in the strictest sense—and would be better called momentum or shock absorber, or alleviator, as was now more common. These devices were usually spring-loaded; in large sizes there were several tiers of springs, and several springs in each tier; this was for the purpose of manufacture and to minimise risks in case of springs failing. Sometimes the device was combined with a relief valve so as to let a relatively small quantity of water escape when a predetermined pressure had been exceeded. The speaker's works were situated at one end of Leeds Waterworks service main, which was subject to the pulsations of pressure or shock waves, and by opening a stop valve a very little the pulsations ceased. As a general precaution in a hydraulic system the speaker recommended a large combined momentum and relief valve being located near the accumulator and an alleviator near each pump and hydraulic machine, but the details of the installation should be in proportion and the whole arranged with intelligence in every case, to arrive at the best results. Weight-loaded accumulators were not ideal, on account of the loading, or the mass, which was not sufficiently sensitive and often increased shock, particularly if the accumulator was on the small side. On board, where accumulators were subject to the rolling and pitching of the ship, the loading was generally done by steam; on land, the speaker was strongly of opinion that compressed air was the best medium for loading hydraulic accumulators and alleviators which really were accumulators in miniature. Mr. Towler proceeded to say that it was undesirable to employ air vessels on the delivery side of hydraulic pumps, because the air escaped whenever the pressure fell; not only was it expensive to replace, but air in hydraulic mains was a source of danger on account of the liability of air locks. It would be understood that in the air loaded accumulators and alleviators recommended, the compressed air was confined in a separate vessel from the water, and should the pressure of the latter fall, the former could not be released. Air vessels on the suction side of pumps were sometimes objected to because they were alleged to have a habit of getting full of water, or empty; if the former, some means should be provided to replenish the air, and, if the latter, it was clear that there was an insufficient water supply to the pump—either the pipes were too small, or there was not a sufficient head. All air vessels should be supplied with water gauges and air-charging devices, and needed periodical attention; the correct water-level generally indicated favourable suction conditions, which were essential to the satisfactory and efficient working of hydraulic pumps.

SHIPS LOSSES AND REPLACEMENT.

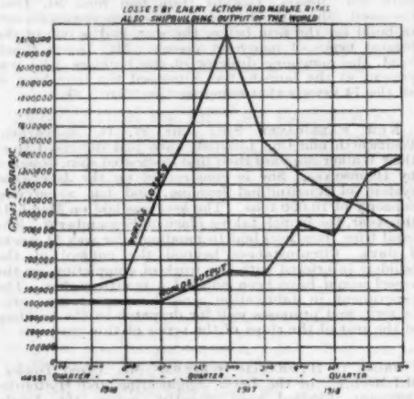
We gave in a former issue, on page 143 *ante*, particulars then available on the output of merchant tonnage in the United Kingdom and Allied and neutral countries. We now complete the information from an announcement made by the Secretary of the Admiralty. Table I gives the output of merchant tonnage down to the third quarter of the present year, and Table II the tonnage of vessels completed in United Kingdom yards and entered for service, down to last month :—

TABLE I.—*Output of Merchant Tonnage.*

Period.	United Kingdom.	Allied and Neutral.	World.
	gross tons.	gross tons.	gross tons.
1915	650,919	551,081	1,202,000
1916	541,552	1,146,448	1,688,000
1917	1,163,474	1,774,312	2,937,786
1918.			
First quarter ..	320,280	550,037	870,317
Second quarter	442,966	800,308	1,243,274
Third quarter ..	411,895	972,735*	1,384,130

* Provisional figures.

The output of the world during the last quarter exceeded the losses from all causes by nearly half a



million gross tons, the figures being : United Kingdom, loss over output 99,156 tons ; Allies and Neutral, output over loss 590,740 tons ; difference, being output over loss, 491,584 tons.

TABLE II.—*Tonnage of Vessels Completed in United Kingdom Yards and Entered for Service.*

1917	Completions. gross tons	1918	Completions. gross tons
January	48,080	January	58,568
February ..	79,451	February ..	100,038
March	118,699	March	161,674
April	69,711	April	111,533
May	69,773	May	197,274
June	109,847	June	134,159
July	83,073	July	141,948
August	102,060	August	124,675
September ..	63,150	September ..	144,772
October	148,309	October ..	136,100
Total ten months to October 31, 1917	892,162	Total ten months to October 31, 1918	1,310,741
Total 12 months to October 31, 1917	1,045,036	Total 12 months to October 31, 1918	1,582,053

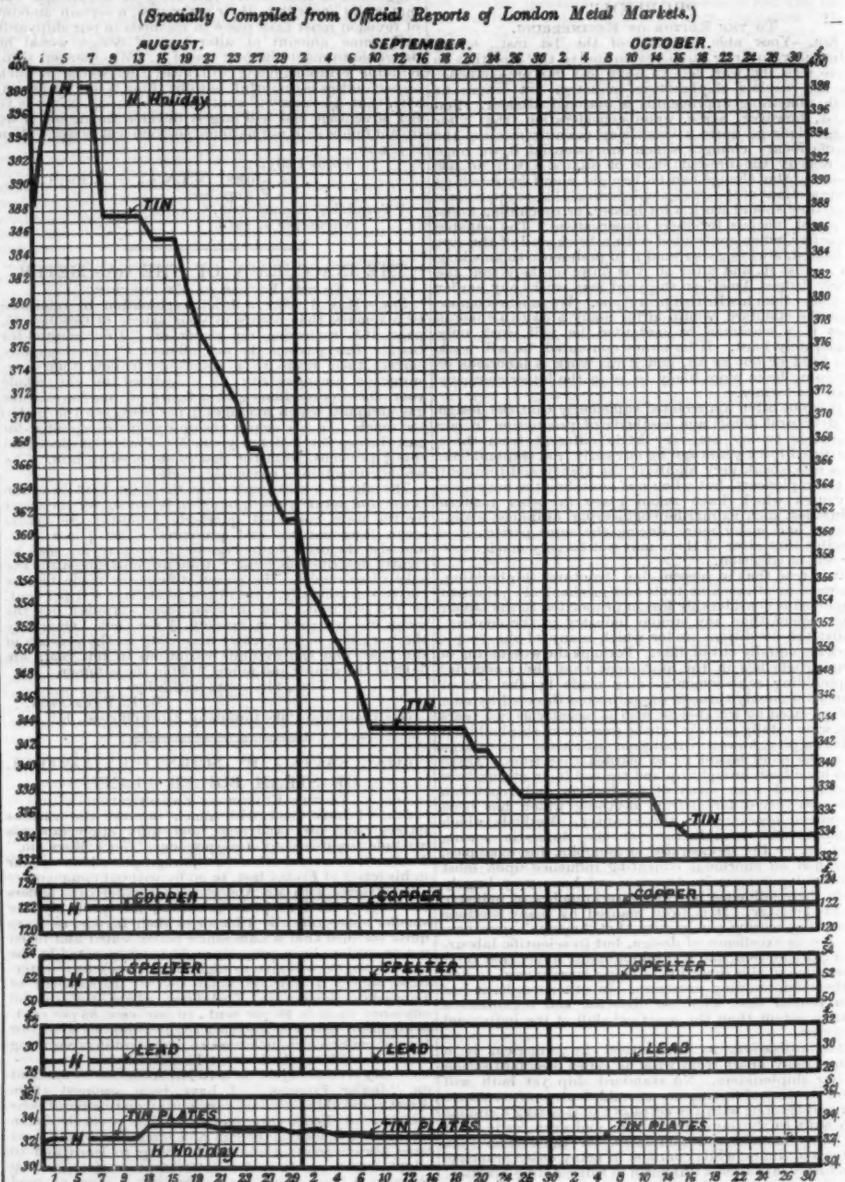
On page 474 *ante*, we illustrated in a diagram the losses and output of merchant tonnage for the United Kingdom. In the diagram herewith we now illustrate the world's losses by enemy action and marine risks and the shipbuilding output of the world down to the third quarter of the present year.

Speaking in Parliament last Wednesday, Dr. Macnamara noted that up to September 30, the gross tonnage of British merchant steamships lost by enemy action and marine risk, was 8,946,000. The loss had been made good to the extent of 5,443,000 gross tons. This left a deficit of 3,503,000 gross tons.

BRAZILIAN REQUIREMENTS OF ROLLING-STOCK.—The prospects of the cotton crop, says *The Board of Trade Journal*, are reflected in the demands of the railways for rolling-stock. For instance, 40 new locomotives is what one railway wants in anticipation of the cotton crop. The Sao Paulo Railways, it is stated, require six new locomotives. This is a normal want. Up to the present the railways have always received all their imported rolling-stock from the United Kingdom.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(*Specially Compiled from Official Reports of London Metal Markets.*)



NOTE.—In the diagrams above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c. ; thus the price of hematite pig iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

THE GERMAN LOCOMOTIVE INDUSTRY.—The secretary of the German Locomotive Union has recently published some information about the German locomotive industry and its prospects during what is now generally called the reconstruction period. He holds that employment will be satisfactory, but that the enhanced capacity of the locomotive factories will not be fully utilised. He estimates the possible output of the north and south German factories at far above 4,000 locomotives per annum, of a weight of more than 200,000 tons. Prior to the war Germany exported about one-fourth of her production of locomotives, large and small, the export accounting for :—

	In Number.	In Weight.
1911	33·4 per cent.	22 per cent.
1912	36·5 ,,	25·3 ,,
First 7 months, 1914	39·3 ,,	23·2 ,,

At present the home consumption has absorbed almost the entire production, so that the German railways, field railways and military railways have now a considerably larger number of locomotives at their disposal than before the war. The German railways have supplied several thousand locomotives to neutrals, allies, and occupied territories. Many of these locomotives, and all the several hundred field railway engines, will come back after the war and be employed on the small lines, for industrial concerns and contractors. This must mean a tangible reduction in the demand for small locomotives. The interrupted international traffic can only again be re-established very slowly. The cessation of orders from abroad and the reduced demand for small locomotives will not nearly be counterbalanced by the home demand. Under these circumstances there is no reason to apprehend any shortage of locomotives on the German railways after the war. As regards prices, the Prussian-Hessian Railway Department made its estimates on an average price for locomotives for the years 1914–17 of 90,000 marks to 100,000 marks.

THE 200-H.P. AUSTRO-DAIMLER AERO ENGINE.

(*Concluded from page* 492.)

Oil Pump and Lubricating System.—The lubrication system of this engine is on the wet sump principle, having one large pump to keep the main oil in circulation, and a smaller pump to supply a small charge of fresh oil to the system at each pump stroke. In this engine the main pump sucks oil from the sump, which is approximately of 7 gallons capacity, and delivers it under pressure to the main journal bearings. The small pump supplies the camshaft with fresh oil taken from the tank cast in the top half of the crank-case. The main oil pump (see Figs 18 and 19) consists of a steel plunger 40 mm. in diameter, working in a cast-iron barrel. This plunger is hollow and has another plunger or ram, 7 mm. in diameter, fitted inside it. Both the barrel of the pump and the small plunger remain stationary, whilst the large plunger is rotated by means of a bronze worm wheel, which floats on a square formed on the plunger. The worm wheel is driven from the crank-shaft by a worm cut on a small inclined shaft. Besides rotating, the plunger is made to reciprocate by means of a scroll cam machined in the plunger, which works against a hardened steel roller fixed into the pump barrel, and thus transmits the reciprocating motion to the plunger, the end of which is plugged and forms the piston of the main pump. The small ram fitted inside is also hollow and works on the same principle, though in this case the barrel moves whilst the ram remains stationary. A port cut in the side of this small plunger is put in communication alternately with the supply pipe from the tank and the delivery pipe to the camshaft, by means of an oil way drilled radially in the main plunger. From the main oil pump the oil is forced along a delivery pipe to the centre of the engine, where it feeds the main oil lead running beneath the crankshaft and connected to each of the journals by vertical branch pipes.

The crankshaft is bored and plugged in the usual manner and conveys oil from the journals to the crank pins, whence the oil is forced up the small pipes attached to the connecting rods into the little end bearings. The delivery pipe from the small pump to the camshaft is taken up the front end of the engine and runs along outside the camshaft casing, being connected to the oil ways drilled in the cover plates by six inclined channels formed in the cover plates, as shown in Fig. 12, page 490 *ante*. From this central oil lead in the cover plates the oil is conveyed to the camshaft bearings by the vertical holes drilled in the ends of the cover plates, and to the inner rocker arms by short cross channels, which deliver the oil into grooves milled in the rocker arms, whence it finds its way to the journals of the hollow rocker spindles and their bearings, and also to the cam rollers and cams. The camshaft casing is always kept full of oil, and provision is made for filling up before starting by three holes fitted with screwed plugs, which are placed in the top of the cover plates. From the camshaft casing the oil overflows through two grooves formed in the side of the front camshaft bearing and thence finds its way to the sump down the vertical spindle casing, lubricating the vertical spindle bearings and gears on its way. The oil sump is exceptionally deep and is fed from the sheet steel false bottom by three pipes, one from each end and one from the centre.

Ignition.—The two Bosch Z.H.6 type magnetos are driven by bevel gears off the bottom end of the camshaft driving spindle at the front of the engine. The magnetos are mounted on aluminium bed plates which are bolted to the top face of the crank chamber, which forms an extension over the auxiliary oil tank. As will be noticed in the illustrations of the engine, the magnetos are placed diagonally, each magneto being driven at an angle of 52 deg. to the crankshaft axis, in a horizontal plane. Two Bosch three-point sparking plugs are fitted to each cylinder on the same side of the engine, being screwed into the combustion heads just below each inlet valve; each magneto, of course, serves one plug in each cylinder. The magneto controls are interlinked with the throttle control, so that when the engine is throttled down the ignition is automatically retarded. The order of firing is as follows:—

Propeller—1, 5, 3, 6, 2, 4.

As shown in the photograph of the induction side view of the engine, Fig. 1, page 488 *ante*, all the high-tension leads from the magnetos are carried in a particularly neat form of cable carrier, which is made of red sheet fibre and is carried on cast aluminium brackets attached to the top of the crank-case.

Carburettor and Induction System.—The duplex carburettor (see Fig. 20, page 538) is on the left side of the engine, and supplies the mixture through two separate galvanised steel induction manifolds; each manifold feeds three cylinders, and is lagged with asbestos. The carburettor is built up in three sections. The bottom section—which is made of gun-metal—contains the two float chambers and the four jets. A common filter chamber fitted with the usual gauze strainer is cast on the front of this portion. The centre portion of the carburettor—which is made of aluminium—contains the butterfly throttles, and the upper portion of the choke tubes.

A large air chamber, cast round the throttle barrels, is used as the outlet for hot air from the crank-case and thus helps to warm the mixture. The top portion of the carburettor consists of a cast aluminium chamber, in which the supply for the two carburettors is united, thus ensuring an equal supply to each manifold. This chamber has a water jacket cast round it, which is connected to the main water circulation system by a pipe at each end.

The annular float chambers encircle the choke tubes. Two jets are fitted in each carburettor, the capacity of the main jet being 35 c.c. per minute, and that of the pilot jets 5·8 c.c. per minute. The filter is fitted with a pressure release valve which discharges into a small chamber below the filter, where it unites with the overflow from the float chambers. The air supply to the carburettors is taken from the false bottom, through a passage cast in the side of the crank chamber, an extra air valve is fitted round the choke tubes.

Petrol Tanks.—In the Austrian "Berg" biplane scouts, fitted with these Austro-Daimler engines, the main petrol tank is under pressure, and is situated at the bottom of the fuselage, behind the engine. A small gravity tank holding 3¼ gallons is also fitted as an emergency fuel tank, just behind the engine in the upper part of the fuselage, and the total air endurance according to report is given at 2¼ hours at 1,000 ft.

Air Pump.—The air pump for the petrol tank pressure is of the spring-loaded plunger type, and is operated by a separate cam on the camshaft between the two rear cylinders. As shown in the sectional arrangement drawing of the compression release gear, it is mounted on the cover of the cast aluminium camshaft casing. A hand pressure pump is also fitted in the machine.

Water Pump.—Fig. 21, page 538, is a section of the complete water pump. This is of the centrifugal type, and as shown in the views of the engine is driven directly off the rear end of the crankshaft by a bevel gear which is integral with a sleeve forming an extension shaft. This is attached to the rear end of the crankshaft, and also drives the gun interrupter gear through a worm gear on a transverse shaft.

The water pump spindle is inclined at an angle of 30 deg. to the crankshaft and runs in phosphor-bronze bearings. The driving bevel gear floats on the end of the pump spindle, and is fitted with a large diameter thrust ball race and retaining spring, which, being at the bottom end of the spindle, are as far away as possible from the rotor of the water pump. Both the pump spindle bearings are well lubricated, through two drilled holes in the pump body and oil grooves cut in the spindle bearings, by a large self-acting grease lubricator which is screwed into the cast aluminium water-pump body. The pump rotor is 112 mm. diameter and is formed with six vanes of the usual Mercedes type. The rotor is keyed to the spindle and secured by a gun-metal nut and washer.

A conically-faced shoulder is machined on the pump spindle directly beneath the rotor. This shoulder beds into the bevelled face of the bronze bearing, forming an efficient water joint. The water pump, although somewhat heavy in its construction, is well designed and is very accessible. The diameter of the intake passage through the cover is 36 mm., and the diameter of the delivery is also 36 mm.

Water-Cooling System.—A "V" type honeycomb radiator is used with this engine, and is mounted at the front of the engine, directly behind the propeller (see Fig. 22). The capacity of the radiator is approximately 4 gallons, and a small barrel-shaped condenser, 4 in. diameter and 5 in. long, is provided on the top of the radiator, apparently to prevent boiling water from escaping and blowing back. No louvres or blind are fitted to prevent over cooling.

From the bottom of the radiator water is circulated through the steel pipe to the inlet of the water pump and is delivered into the bottom of each of the cylinder water jackets. These are coupled together in the usual way by rubber joint rings and clips, both at the bottom of the water jackets and in the water passages above the valves in the cylinder heads. The construction of these joint rings is interesting, consisting of bevelled rubber rings, reinforced in the centre with a steel spring ring. The rubber joint rings are expanded into the outside of the conical faces of the steel water connections on the cylinders by the halves of a split aluminium ring, which are clamped together by a band clip of ordinary design. From the results and appearance of the engine during tests these water joints are very efficient. Circulating through the cylinder water jackets, the water passes to the top of the radiator through two passages cast in the front end of the aluminium camshaft casing. These water passages encircle the camshaft just behind the driving bevel gears.

Revolution Indicators.—A flexible drive for the engine speed indicator is driven directly off the rear end of the camshaft in a small extension chamber, and some form of revolution indicator was apparently mounted in the

Fig. 18.

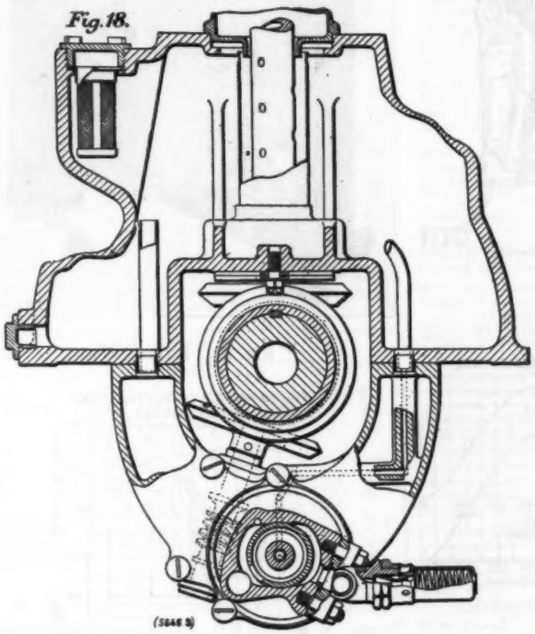
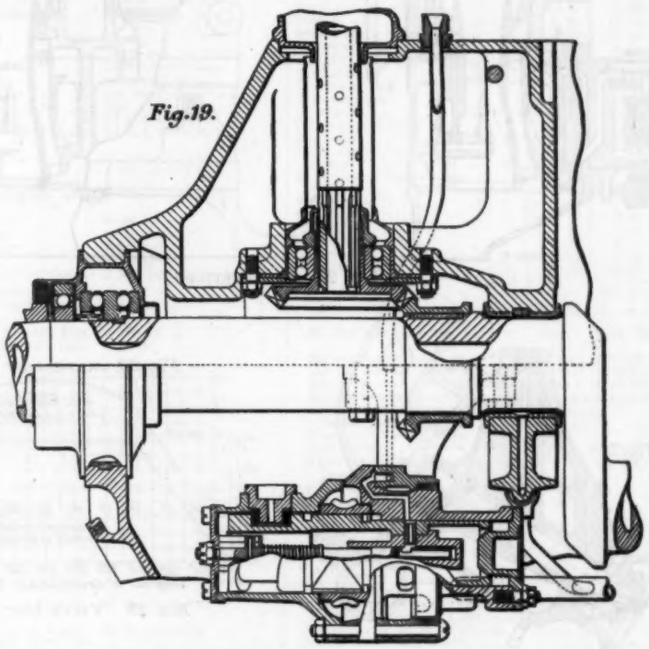


Fig. 19.



FIGS. 18 AND 19. DETAILS OF OIL PUMP AND OIL TANK.

centre of the "V" radiator. Unfortunately the instrument is missing, but a portion of the driving mechanism is shown in the general arrangement, Fig. 3, on page 489 *ante*, from which it will be seen that the gear employs a small diameter worm mounted about half-way up the vertical driving shaft. This engages with a worm pinion which drives a trip-gear pinion at a speed ratio of approximately 1 : 100.

Wireless Generator.—A flange is machined on the rear extension of the crankshaft to take a belt driving pulley for the wireless dynamo. This pulley is probably of the standard friction clutch type used on all enemy engines.

Exhaust.—No exhaust manifold or silencer is provided, but a separate short exhaust pipe about 12 in. long, of streamline section, extends from each cylinder. These are shown in the view of the engine, Fig. 2, on page 488 *ante*.

Conclusions.—The design of this new type Austro-Daimler engine, as set out in the foregoing detailed description, and the following data and test results, shows a careful study of details. Both in its general lay-out and in most of its details of construction this engine undoubtedly possesses more originality in design than the majority of enemy engines up to the present time. The design of the lubrication and oil-cooling system has evidently been carefully considered, as have also the carburettor and induction systems.

The new type of scroll cam oil pump is interesting, but in its present form is excessively heavy. This type of oil pump, however, it is interesting to note, is now used on the new 270-h.p. Basse Selve engines. In these engines the oil pump works on exactly the same principle, but is duplex and is relatively much lighter, the body of the pump being made of cast aluminium instead of cast-iron.

The 200-h.p. Austro-Daimler engine would be very suitable for installation in any of the small enemy scout machines which use the 180-h.p. Mercedes engines, but, speaking generally, the new Austro-Daimler engines need hardly be considered as a serious effort to compete with any of the Allied aero engines of the same rating and proportions.

This engine is at the Enemy Aircraft View Rooms, Islington, and may be seen on production of a pass obtainable by written application to—The Controller, Technical Department, Ap.D. (L.), Central House, Kingsway, W.C. 2.

R.A.E. Calibration and Endurance Test Report.

The 200-h.p. Austro-Daimler engine was coupled to a Heenan and Froude dynamometer, and run for the usual calibration and 1 hour endurance tests. Power, throttle and consumption curves are given in Fig. 24.

Calibration Results.

Revolutions per minute..	1,300	1,400	1,500	1,600
Brake horse-power ..	186	200	212	222
Brake M.E.P.	123·5	123·3	122	119·7
Petrol consumption in Pints/b.h.p./hour ..	0·55	0·545	0·546	0·548

Endurance Test.—The engine was submitted to an endurance test of 1 hour's duration at normal revolutions, i.e., 1,400 r.p.m., with the following results :—

Average output	202 b.h.p.
Average speed	1,400 r.p.m.
Petrol consumption per hour..	14 gallons.
Petrol consumption per b.h.p.-hour	0·555 pint per b.h.p.-hour.
Oil consumption per hour ..	7 pints.
Oil pressure	5 lb. per sq. in.
Oil temperature	50 deg. C.
Water temperature (inlet) ..	54·5 deg. C.
Water temperature (outlet) ..	60 deg. C.
Total duration of tests ..	10 hours 25 minutes.
Complete weight of engine ..	728·5 lb. dry.

Weight per Brake Horse-Power.

At 1,300 r.p.m.	= 3·81 lb. per b.h.p.
1,400 ,,	= 3·64 ,,
1,500 ,,	= 3·43 ,,
1,600 ,,	= 3·28 ,,

Running during 1 Hour Endurance Test.—Very steady between 700 r.p.m. and 1,700 r.p.m. At 500 r.p.m. vibration was bad, and below this speed running was generally unsteady.

Distribution.—Very good.

Cleanliness.—Throughout the test the engine kept remarkably clean. No trace of oil or water leakage was observed.

Troubles Experienced on Test.—The K.L.G. spark plugs fitted for the test gave trouble by shorting internally. The valve tappets required to be readjusted during the test.

Test of Water Pump.—Speed of the water pump spindle = 1·834 : 1 crankshaft revolution. The delivery of the water pump under varying pressures has been made the subject of a separate test, the results of which are given in the following test report and delivery curves, Fig. 25. The pump has coupled to an electric motor and run with the following results :—

R.P.M.	Pressure.	Delivery.
1,800	2 lb. per sq. in.	42 gallons per min.
1,800	4 ,,	43 ,,
1,800	6 ,,	28·5 ,,

The weight of the complete water pump = 7·6 lb.

Fig. 20.

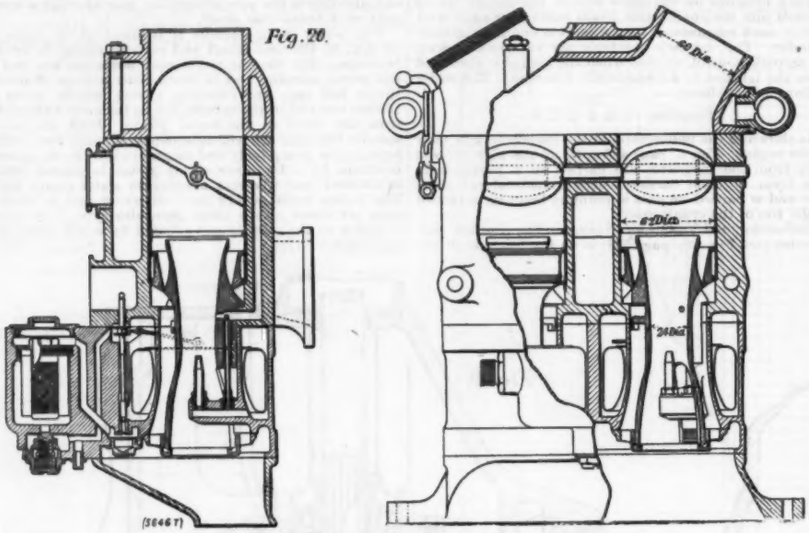


FIG. 20. CARBURETTOR.

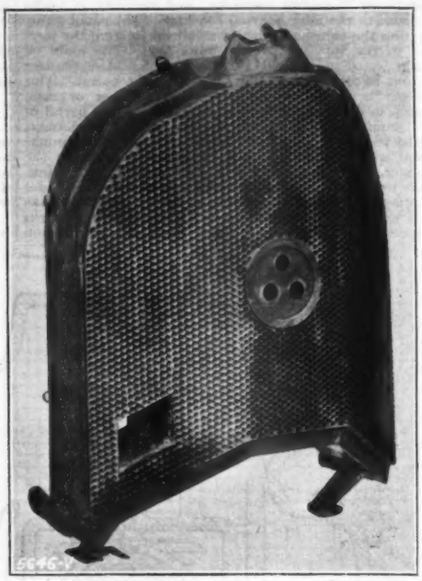


FIG. 22. RADIATOR.

Fig. 21.

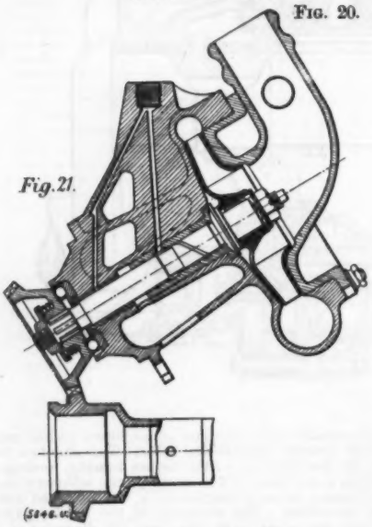


FIG. 21. WATER PUMP.

Fig. 23. VALVE LIFT DIAGRAM.

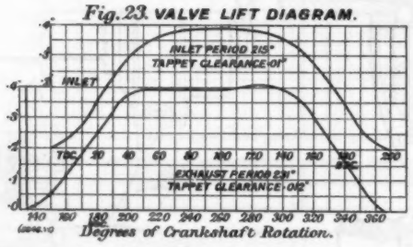


FIG. 23. VALVE LIFT DIAGRAM.

Fig. 24. POWER, THROTTLE AND CONSUMPTION CURVES.

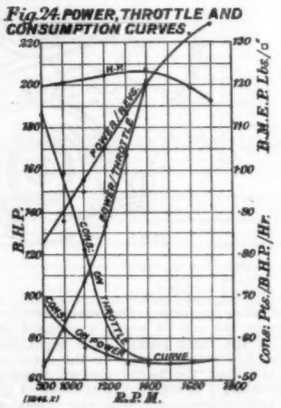
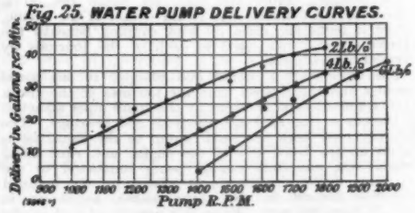


Fig. 25. WATER PUMP DELIVERY CURVES.



R.A.E. Metallurgical Test Report.

The chemical compositions and the relative material strengths of the principal parts of the engine are given in the following chemical analysis and mechanical test reports :—

General Data.

Make of engine and rated h.p. ..	Austro-Daimler 200-h.p.
Number of cylinders	Six.
Type number	8597.
Bore	135 mm. (5·31 in.).
Stroke	175 mm. (6·89 in.).
Stroke/bore ratio	1·29 : 1.
Area of one piston	143·1 sq. cm. (22·2 sq. in.).
Total piston area of engine ..	858·6 sq. cm. (133·1 sq. in.).
Swept volume of one cylinder ..	2,504·9 cub. cm. (152·8 cub. in.).

(1) *Chemical Analysis.*

—	C. per cent.	Si. per cent.	Mn. per cent.	S. per cent.	P. per cent.	Cr. per cent.	Ni. per cent.
Crankshaft	0·14	0·27	0·43	0·030	0·006	1·34	3·45
Cylinder	0·47	0·19	0·67	0·037	0·046	nil	nil
Connecting rod	0·40	0·16	0·73	0·043	0·023	0·36	1·50
Camshaft (case-hardened)	—	0·21	0·43	0·035	0·012	0·57	3·15
Inlet valve	0·46	0·24	0·42	0·023	0·022	0·47	2·28
Exhaust valve	0·44	0·24	0·41	0·025	0·022	0·47	2·36
Valve rocket	0·46	0·09	0·63	0·051	0·028	0·42	1·57
Gudgeon-pin (case-hardened)	—	0·12	0·49	0·028	0·011	1·15	3·70

(2) *Chemical Analysis.*

	Crank-case.	Piston.
	per cent.	per cent.
Copper	2·79	7·67
Zinc	6·61	1·33
Tin	Nil.	2·21
Silicon	0·76	0·52
Iron	2·06	1·32
Manganese	0·02	Trace
Nickel	—	Nil.
Magnesium	—	0·29
Aluminium (by difference)	87·76	86·66

(3) *Bearings.*

—	Journal Bearings.	Big-End Bearings.	Camshaft Bearings.	Valve Rocker Bearings.
	per cent.	per cent.	per cent.	per cent.
Copper	6·70	5·10	87·51	96·29
Zinc	—	—	0·28	Trace
Tin	81·13	81·42	11·34	2·52
Lead	0·71	1·64	0·17	0·28
Antimony	12·00	12·00	—	—
Manganese	—	—	Nil	0·21
Nickel	—	—	0·35	0·07
Iron	—	—	0·17	0·13
Phosphorus	—	—	0·05	—

(4) *Mechanical Tests.*

Position.	Mark.	No.	Area sq. in.	Y.S. T. per Sq. in.	M.S. T. per Sq. in.	Elong. Per cent.	Red. of Area Per cent.	Impact Ft. lbs.
Journal	A	1	0·002	66·7	75·1	13·33	57·4	—
Journal	B	2	—	—	—	—	—	30·5
Pin	C	3	0·005	62·7	72·5	15·55	59·8	—
Pin	D	4	—	—	—	—	—	33·5
Web longitudinal	E	5	0·005	71·6	75·8	10·0	35·0	—
Web longitudinal	F	6	—	—	—	—	—	7·5
Web transverse	G	7	0·005	72·9	74·5	7·78	25·1	—
Web transverse	H	8	—	—	—	—	—	(1) 5·0 (2) 7·0

Total swept volume of engine	15,029·7 cub. cm. (916·8 cub. in.).
Clearance volume of one cylinder	623·1 cub. cm. (38 cub. in.)
Compression ratio	5·02 : 1.
Normal b.h.p. and speed	200 b.h.p. at 1,400 r.p.m.
Maximum ditto	222 b.h.p. at 1,600 r.p.m.
Normal B.M.E.P.	123·3 lb. per sq. in. at 1,400 r.p.m.
Maximum ditto	123·5 lb. per sq. in. at 1,300 r.p.m.
Piston speed	1,607 ft. per minute.
Mechanical efficiency (calculated)	89·7 per cent.
Indicated mean pressure (calculated)	137·5 lb. per sq. in.
Fuel consumption per b.h.p.-hour	0·555 pint = 0·499 lb.
Brake thermal efficiency	27·4 per cent.
Indicated thermal efficiency	30·6 per cent.
Air standard efficiency	47·5 per cent.
Relative efficiency	64·4 per cent.
Cub. in. of swept volume per b.h.p	4·58 cub. in.
Sq. in. of piston area per b.h.p.	0·665 sq. in.
H.P. per cub. ft. of stroke volume	377·3 b.h.p.
H.P. per sq. ft. of piston area	216·6 b.h.p.
Direction of rotation of crankshaft	Anti-clockwise.
Direction of rotation of propeller	Ditto.
Type of gear reduction to propeller	None.
Ratio crankshaft speed/propeller speed	1 : 1.
Type of valve gear	Overhead camshaft.
Type of starting gear	Compression release.
Carburettors—	
Number and type of carburettors	One dual Austro-Daimler.
Diameter of choke tube	24 mm. (0·945 in.).
Bore of main jets	35 c.c. through per min.
Bore of pilot jets	5·8 c.c. through per min.
Fuel consumption per hour	111 pints = 100 lb.
Fuel consumption per b.h.p.-hour	0·555 pint = 0·499 lb.
Gas Velocities, Valve Area, &c.—	
Diameters—	
Induction pipe	59 mm. (2·32 in.).
Inlet and exhaust effective valve ports (each)	44 mm. (1·73 in.).
Inlet and exhaust cylinder ports (each)	42 mm. (1·65 in.).
Cross-Sectional Areas—	
Induction pipe	27·33 sq. cm. (4·22 sq. in.).
Inlet valve (π d h)	13·69 sq. cm. (2·12 sq. in.).
Exhaust valve (π d h)	14·05 sq. cm. (2·18 sq. in.).
Exhaust branch pipes	38·25 sq. cm. (5·92 sq. in.).
Mean Gas Velocities (1,400 r.p.m.)—	
Induction pipe	141 ft. per sec.
Inlet valves	140 ft. per sec.
Exhaust valves	136 ft. per sec.
Exhaust branch pipe	100·5 ft. per sec.
Inlet Valves—	
Number per cylinder	Two.
Largest diameter	48 mm. (1·89 in.).
Effective valve port diameter	44 mm. (1·73 in.).
Width of seating	2·5 mm. (0·09 in.).
Angle of seating	45 deg.
Lift of valve	9·9 mm. (0·39 in.).
Diameter of stem	10 mm. (0·39 in.).
Length of valve guide	68 mm. (2·67 in.).
Overall length of valve	135 mm. (5·315 in.).
Number of springs per valve	One.
Free length of spring	60 mm. (2·36 in.).
Length of spring in position (no lift)	46 mm. (1·81 in.).
Mean diameter of coils	34 mm. (1·34 in.).
Diameter of wire	4 mm. (0·157 in.).
Ratio length of spring/lift of valve	4·61 : 1.
Weight of valve complete with spring	0·50 lb.
Weight of spring bare	0·16 lb.
Inlet valve opens	10 deg. early.
Inlet valve closes	30 deg. late.
Period of induction	220 deg.
Inlet valve tappet clearance	0·25 mm. (0·01 in.).
Exhaust Valves—	
Number per cylinder	Two.
Largest diameter	48 mm. (1·89 in.).
Effective valve port diameter	44 mm. = 1·73 in.
Width of seating	2·5 mm. (0·09 in.).
Angle of seating	45 deg.
Lift of valve	10·16 mm. (0·40 in.).
Diameter of stem	10 mm. (0·39 in.).
Length of valve guide	68 mm. (2·67 in.).
Overall length of valve	135 mm. (5·315 in.).
Number of springs per valve	One.
Free length of spring	60 mm. (2·36 in.).
Length of spring in position (no lift)	46 mm. (1·81 in.).
Mean diameter of coils	34 mm. (1·34 in.).
Diameter of wire	4 mm. (0·157 in.).
Ratio length of spring/lift of valve	4·6 : 1.
Weight of valve complete with spring	0·50 lb.
Weight of spring bare	0·16 lb.
Exhaust valve opens	45 deg. early.
Exhaust valve closes	7 deg. late.
Period of exhaust	232 deg.
Exhaust valve tappet clearance	0·304 mm. (0·012 in.).
Inertia Forces, Bearing Loads, &c.—	
Weight of piston complete with rings and gudgeon-pin	4·18 lb.
Weight per sq. in. of piston area	0·188 lb.
Weight of connecting rod complete	4·84 lb.
Weight of reciprocating part of connecting rod	1·66 lb.
Total reciprocating weight per cylinder	5·84 lb.
Weight per sq. in. of piston area	0·263 lb.
Length of connecting rod (centres)	315 mm. (12·40 in.).
Ratio connecting rod/crank throw	3·6 : 1.
Inertia lb. per sq. in. piston area top centre	63·8 lb. per sq. in.
Inertia lb. per sq. in. piston area bottom centre	36·2 lb. per sq. in.
Inertia lb. per sq. in. piston area mean	25 lb. per sq. in.
Weight of rotating mass of connecting rod	3·18 lb.
Total centrifugal pressure	610 lb.
Centrifugal pressure lb. per sq.in. piston area	27·5 lb. per sq. in.
Mean average fluid pressure including compression	47 lb. per sq. in.
Mean average loading on crank-pin bearing, total from all sources in terms of lb. per sq. in. piston area	91 lb. per sq. in.
Diameter of crank-pin	56 mm. (2·20 in.).
Rubbing velocity	13·42 ft. per sec.
Effective projected area of big-end bearing	32·4 sq. cm. (5·02 sq. in.).
Ratio piston area/projected area of big-end bearing	4·42 : 1.
Mean average loading on big-end bearing	402 lb. per sq. in.
Load factor on big-end bearing	5,400 lb. per ft. sec.
Cylinders—	
Overall height of bare cylinder from top of base chamber	365 mm. (14·370 in.).
Depth of spigot at base of cylinder	15 mm. (0·590 in.).
Diameter of cylinder over water jacket	160 mm. (6·29 in.).
Thickness of flange at base of cylinder	11 mm. (0·433 in.).
Number of holding-down bolts per cylinder	Eight.
Diameter of holding-down studs	4 of 14 mm. 4 of 19 mm.
Thickness of water jacket	1 mm. (0·039 in.).
Mean thickness of combustion chamber wall	5 mm. (0·197 in.).
Thickness of cylinder barrel (top)	4 mm. (0·177 in.).
Thickness of cylinder barrel (centre)	3 mm. (0·138 in.).
Thickness of cylinder barrel (bottom)	4 mm. (0·157 in.).
Diameter of water connections between cylinders	36 mm. (1·42 in.).
Piston—	
Type of piston	Aluminium; internal ribs.
Diameter at top	134 mm. (5·275 in.).
Diameter at bottom	134·58 mm. (5·297 in.).
Length	110·5 mm. (4·35 in.).
Ratio, piston length cylinder bore	0·82 : 1.
Number of rings per cylinder	Three.
Position of rings	Above gudgeon-pin.
Width of rings	7 mm. (0·275 in.).
Gap of rings in cylinder	0·48 mm. (0·019 in.).
Connecting Rod—	
Length between centres	315 mm. (12·40 in.).
Ratio connecting rod/crank throw	3·6 : 1.
Little end bearing, type	Plain phosphor-bronze.
Little-end bearing, diameter	28 mm. (1·10 in.).
Little-end bearing, length	67 mm. (2·64 in.).
Little-end bearing, projected area	18·70 sq. cm. (2·90 sq. in.).
Ratio piston area/projected area, little-end bearing	7·66 : 1.

General Analysis of Weights.

Description of Part.	No. per Set.	Average Unit Weight in Lb.	Weight of Complete Set in Lb.	Percentage of Total Weight.
Cylinders, bare	6	18·43	110·62	15·30
Detachable inlet valve pockets	6	1·06	6·37	0·87
Pistons, complete with rings	6	3·52	21·12	2·90
Gudgeon pins	6	0·66	4·00	0·54
Connecting rods	6	4·84	29·04	3·98
Crankshaft	1	96·50	96·50	13·24
Inlet valves	12	0·34	4·12	0·56
Exhaust valves	12	0·34	4·12	0·56
Inlet exhaust valve springs	24	0·16	3·88	5·53
Valve collars and locking cones	24	0·09	2·19	0·30
Valve rockers (with bearings)	12	1·25	15·00	2·06
Camshaft	1	10·25	10·25	1·40
Camshaft casing complete	1	34·50	34·50	4·74
Half compression gear	1	2·69	2·69	0·36
Vertical camshaft driving spindle (complete)	1	6·81	6·81	0·93
Vertical spindle housing	1	1·62	1·62	0·22
Camshaft bevel sprocket	1	3·15	3·15	0·43
Crank-case, top half	1	107·00	107·00	14·68
Crank-case, bottom half	1	73·50	73·50	10·09
Bearing caps	7	2·27	15·93	2·19
Main holding-down bolts	14	0·75	10·50	1·44
Thrust race, complete	1	5·28	5·28	0·72
Propeller hub	1	11·31	11·31	1·55
Carburettors	1	24·06	24·06	3·30
Induction pipes	2	4·25	8·50	1·16
Exhaust pipes	6	2·33	14·00	1·92
Oil pump	1	11·81	11·81	1·62
Oil leads with relief valve	1	4·56	4·56	0·62
Magnetos	2	14·37	28·75	3·94
High tension leads with casing	1	4·75	4·75	0·65
Magneto and throttle controls	1	2·12	2·12	0·29
Water pump	1	7·62	7·62	1·04
Water pipes	1	6·56	6·56	0·90
Air pump	1	1·62	1·62	0·22
Rev. counter drive	1	0·75	0·75	0·10
Gun gear with case	1	5·81	5·81	0·80
Miscellaneous parts	1	28·09	28·09	3·85
Total	—	—	728·50	100·00

Big-end bearing, type	Bronze shell, lined white metal.
Big-end bearing, diameter	56 mm. (2·20 in.).
Big-end bearing, length (actual)	67 mm. (2·63 in.).
Big-end bearing, length (effective)	58 mm. (2·28 in.).
Big-end bearing, projected area	28·4 sq. cm. (5·02 sq. in.).
Ratio piston area/projected area, big-end bearing	4·42 : 1.
Number of big-end bolts	Four.
Full diameter of bolts	10 mm. (0·39 in.).
Total cross-sectional area, bottom of threads	2·04 sq. cm. (0·316 sq. in.)
Pitch of threads	1·5 metric.
Maximum load due to inertia at 1,400 r.p.m.	1,390 lb.
Maximum load due to inertia at 1,600 r.p.m.	1,815 lb.
Load due to centrifugal force at 1,400 r.p.m.	370 lb.
Load due to centrifugal force at 1,600 r.p.m.	485 lb.
Total load on bolts at 1,400 r.p.m.	1,760 lb.
Total load on bolts at 1,600 r.p.m.	2,300 lb.
Stress per sq. in. at 1400 r.p.m.	5,570 lb. per sq. in.
Stress per sq. in. at 1,600 r.p.m.	7,280 lb. per sq. in.
Crankshaft—	
Number and type of main bearings	Seven, bronze cage, lined white metal.
Cylinder centres	166 mm. (6·53 in.).
Crank-pins—	
Outside diameter	56 mm. (2·20 in.).
Inside diameter	30 mm. (1·18 in.).
Length	68 mm. (2·67 in.).
Journals—	
Outside diameter	58 mm. (2·28 in.).
Inside diameter (front two)	21 mm. (0·82 in.).
Inside diameter (others)	30 mm. (1·18 in.).
Length, prop. end	56 mm. (2·20 in.).
Length, rear end	43·5 mm. (1·71 in.).
Length, centre	50 mm. (1·97 in.).
Length, intermediate	50 mm. (1·97 in.).
Crank Webs—	
Width	74 mm. (2·91 in.).
Thickness (front two)	24·5 mm. (0·96 in.).
Thickness (others)	24 mm. (0·94 in.).
Radius at ends of journals and crank-pins	4·5 mm. (0·17 in.).
Weight of complete shaft	96·5 lb.
Working Clearances—	
Piston clearance, top (total)	1 mm. (0·039 in.).
Piston clearance bottom (total)	0·42 mm. (0·016 in.).
Side clearance of connecting rod in piston (total)	2·50 mm. (0·098 in.).
Side clearance of connecting rod on crank-pin (total)	1 mm. (0·039 in.).
End clearance of crankshaft in main bearings	2 mm. (0·079 in.).
Lubrication System—	
Number and type of oil pumps	One plunger.
Oil consumption per hour	7 pints.
Oil consumption per b.h.p.-hour	0·035 pint = 0·039 lb.
Oil pressure	5 lb. per sq. in.
Oil temperature	50 deg. C.
Specific gravity of oil	0·899.
Ratio, pump speed/crankshaft speed	1 : 15.
Ignition—	
Number and type of magnetos	Two Bosch Z.H.6.
Firing sequence of engine	Prop. 1-5-3-6-2-4.
Ignition timing (fully advanced)	20 deg. E. to 40 deg. E variable.
Number of plugs per cylinder	Two.
Type of plugs	Bosch 3 point.
Ratio magneto speed/crankshaft speed	1·5 : 1.

Cooling System—	
Number and type of water pumps	One centrifugal.
Diameter of inlet pipe	36 mm. (1·42 in.).
Diameter of outlet pipe	36 mm. (1·42 in.).
Diameter of rotor	112 mm. (4·40 in.).
Number and type of radiators ..	One Honeycomb.
Ratio water pump speed/engine speed	1·894 : 1.
Water temperature inlet ..	54·5 deg. C.
Water temperature outlet ..	60 deg. C.
Air Pump—	
Type of air pump	Cam-operated plunger.
Bore	38 mm. (1·496 in.).
Weights—	
Weight of complete engine, dry, with propeller boss and exhaust manifold	728·5 lb.
Weight per b.h.p. ditto	3·64 lb.
Weight of fuel per hour	100 lb.
Weight of oil per hour	7·86 lb.
Total weight of fuel and oil per hour	107·86 lb.
Gross weight of engine in running order, less fuel and oil (cooling system at 0·65 lb. per b.h.p.)	858·50 lb.
Weight per b.h.p. ditto	4·29 lb.
Gross weight of engine in running order, with fuel and oil for 6 hours' running (tankage at 10 per cent. weight of fuel and oil)	1,570 ·4 lb.
Weight per b.h.p.	7·85 lb.
Overall Dimensions—	
Height	1,150 mm.
Length	1,724 mm.
Width	568 mm

THE STANDARDISATION OF TESTS FOR REFRACTORY MATERIALS.*

Communicated, with an Introduction, by COSMO JOHNS, F.G.S., M.I.Mech.E.

INTRODUCTION.

PROGRESS in the improvement of refractory materials can only be slow and uncertain if the only available test of their efficiency is that of behaviour under service conditions. This must, of course, be the final and conclusive test, but the use of refractory materials for metallurgical and other structures can only be said to be placed on a scientific basis when their desired properties can be specified and tested in measurable quantities. This involves a knowledge of methods of testing, and in the case of transactions between the maker and user there should be agreement as to the methods of testing to be employed.

In the gas industries considerable progress has been made, and specifications have been drawn up for the principal refractories employed. In the present state of knowledge this is not possible for the more exacting requirements of metallurgical structures where much higher temperatures obtain and corrosive slags and dust-laden gases moving at considerable velocities add to the difficulties of the metallurgical engineer. Before this can be achieved for the iron and steel industries much more must be done in measuring the properties of the various materials available. In order that this might be facilitated a committee† was appointed to draw up a report on the Standardisation of Tests for Refractory Materials by the Refractories Section of the Ceramic Society. Their report was adopted at the Sheffield meeting of the Section, with a recommendation that it should be submitted to the Iron and Steel Institute for discussion and criticism. The report now appears as an appendix to this communication with the object of enabling the members interested to criticise, approve, or to suggest revisions where their experience indicates the desirability.

The method suggested for the analysis of the acidic materials is well known, and it is not expected that any revision will be suggested, but there is a feeling that the method given for the analysis of dolomite and magnesite might possibly be susceptible of useful revision. Any constructive criticism in that direction would receive careful consideration by the committee. The ultimate analysis of any refractory material is, however, of but limited value, for refractories used in industrial operations are never pure substances, and it is the concentration of certain constituents that largely determine the refractory value of the material. Hence it is largely in the direction of physical tests that we must look when we desire to determine the suitability of refractories for the purpose intended. The leading manufacturers have paid considerable attention of late to these methods, and a large amount of data is being accumulated. It is very desirable that users, especially those operating on a large scale, should, having regard to the importance of the subject, interest themselves in the problem. The failure, or shortened life, of a metallurgical structure such as a blast-furnace, coke-oven, or open-hearth furnace, owing to unexpected variations in the quality of the refractory materials employed, is a serious matter, and the consequential losses are out of all proportion to variation in the cost of the refractories themselves.

The physical tests described in the appendix are simple, but they require, if the results obtained are to be comparable with those of other workers, the use of suitable apparatus and a knowledge of the principles involved. In the case of silica and siliceous bricks it is sometimes useful to know the particular form in which the silica occurs. The method described by Dr. Thomas is the only reliable one available. Less reliable methods are probably responsible for the contradictory determinations recorded in the literature of the silica minerals. It is questionable, however, whether a determination of the quartz, tridymite and cristobalite ratio in a silica brick would, in the present state of knowledge, enable us definitely to attribute a figure of merit to the brick under investigation.

The porosity, shrinkage, and tensile strength tests require no comments, but the determination of the volume changes, normal refractoriness, and crushing strength at high temperatures, involves the important question of temperature determinations and the rate of heating employed. The committee recommend, in each test, the use of Seger cones, and state explicitly the desired rate of heating. Seger cones, like the materials under test, have no distinct fusion-point, but a considerable softening range. A silica brick does not fail by complete fusion of the overheated portion, but by the selective fusion of the matrix, in which the larger silica fragments may be observed unaltered. In the course of normal wear the heated surface becomes almost homogeneous at the high temperature employed, both matrix and aggregate having formed a solution. In most refractory materials it is the refractoriness of the matrix or bond that determines its usefulness. As the temperature at which failure occurs depends on the rate of heating, this factor requires careful attention. In the case of normal refractoriness the weight of opinion leans to the use of Seger cones as temperature indicators, but expressing the refractoriness in Seger cone numbers and employing a defined rate of heating. The present writer has, however, suggested that in the refractory test under load, having regard to the extreme value of the data sought for, the actual temperature should be determined. The data required are expressed as the strain under a particular stress at a definite temperature, and for this the use of pyrometers would be necessary. The same might be urged for determining the thermal or reversible expansion. We have here obvious cases where there is room for differences of opinion, and constructive criticism would be welcomed.

The appendix is Part I only of the report, Part II being still under consideration. Eventually it is hoped that knowledge will have progressed sufficiently for the drawing up of specifications for the more important refractory materials used in the iron and steel industries to be undertaken. Such specifications, when agreed upon and based on exact methods of testing, would be welcomed by the leading makers, but their preparation will be a matter of considerable labour, and will require the closest association of qualified representatives of both users and makers of refractory materials and the assistance of experienced workers who have specialised in the scientific side of the subject. Most fortunate would it be if this could be done under the auspices of a National Association for Refractory Research in which this Institute was represented.

APPENDIX.

PROVISIONAL SPECIFICATION.

Standard Methods of Testing Refractory Materials.

Prepared by a committee of the Refractories Section of the Ceramic Society.

The purpose of the present report is to draw up a standard scheme for conducting tests on refractory materials. This should be a prelude to a specification of tests which particular types of refractory material should withstand when used in a particular furnace or in a particular part of a furnace. The Refractory Materials Committee of the Institution of Gas Engineers has laid the foundation for specification work, and it became obvious to that Committee, as the building progressed, that attention should also be directed to the mode of testing the materials in order that comparable results should be obtained by maker and user. That committee has kindly given permission to use such of their data as are considered necessary for the present report. In spite of the greatest care, it is anticipated that this provisional report will have all the blemishes which pertain to first attempts at standardisation, but it is hoped that as experience grows the defects will be eliminated, and weakness strengthened by earnest criticism.

Two types of tests are available, namely, those which allow the results to be expressed precisely as a definite number, and those in which the results can be expressed only in less definite or in vague terms. For example, the differences in the action of different types of flue dust cannot be expressed by number, and a series of comparative terms have to be employed, which have more or less a personal significance. Many useful "homely" tests are not suited for comparative measurement, and consequently are not suited for standardised tests. Such tests have to be excluded from a report on standard methods of testing as a preliminary to specification work. The tests are not necessarily intended for checking the materials in a fireclay works, since that is the private business of the firm itself. For example, a mere determination of the loss on ignition of a dried clay may suffice to show whether the clay and grog have been mixed in the right proportions; and the treatment of silica material with hydrofluoric and sulphuric acids may also suffice for checking the mixing. In any case, the final product should satisfy the specification when tested according to standard processes.

1. THE ANALYSIS OF FIRECLAYS, RAW GANISTERS, QUARTOSE ROCKS, AND MANUFACTURED PRODUCTS.

It is scarcely possible to over-emphasise the importance of getting a fair average or representative sample of all materials for analysis or testing.

Determination of Hygroscopic Moisture.—About 5 grammes of the finely-ground clay are dried in a toluene oven or air-bath maintained at 110 deg. until there is no further loss in weight—3 hours to 4 hours is usually sufficient.

Determination of the Loss on Ignition.—About 1 gramme of the dry clay is heated in a platinum crucible, first over a small flame, then over a Méker or Teclu burner, and finally over a blowpipe flame for about 20 minutes. The crucible is allowed to cool in a desiccator and weighed. The crucible and contents are again heated over the blowpipe flame for 5 minutes, cooled, and weighed. Low results are usually due to the incomplete combustion of the carbon; high results may be due to losses by spurting produced by heating too rapidly.*

Determination of Silica.—The ignited clay in the platinum crucible is intimately mixed with 10 grammes to 15 grammes of sodium carbonate. The mixture is gently heated over a Méker or Teclu burner, and finally fused at a bright red heat for 30 minutes for firebricks, and 15 minutes to 20 minutes for fireclays or silica materials, or until the contents of the crucible are in a state of quiet fusion. The red-hot crucible is dipped in water to about two-thirds of its depth in order to solidify the contents rapidly. The cake is extracted with as small an amount of water as possible, and the washings collected in a 250-c.c. basin—the cake will probably be detached from the crucible by this treatment, and is transferred to the basin. The basin is almost covered with a clock-glass, and 30 c.c. to 35 c.c. of concentrated hydrochloric acid are run into the basin; the covered basin is kept warm on a water bath until all action has subsided and the cake has disintegrated, and any large pieces which remain are crushed into powder with a small agate pestle. The platinum crucible and lid are washed with hydrochloric acid and hot water, and the washings poured into the basin. The solution is evaporated to dryness, and the contents heated in an air oven at 110 deg. until dry. The mass is moistened with concentrated hydrochloric acid, 60 c.c. to 70 c.c. of hot water added and the liquid filtered; the precipitate is washed with hot water until free from chlorides. The filtrate is returned to the basin, evaporated to dryness, and the mass is heated as before until it is free from hydrochloric acid. The residue is again digested with hydrochloric acid and about 60 c.c. to 70 c.c. of hot water, filtered, and the residue washed with hot water until free from chlorides.

The two filter papers are transferred to a weighed platinum crucible, and charred slowly without flame. The carbon is burnt off slowly, and the crucible and its contents heated over the blowpipe for 15 minutes with the lid off, and then 5 minutes with the lid in position. The result is entered as "uncorrected weight of crucible plus silica." The silica contains small quantities of the oxides of titanium, phosphorus, aluminium, and iron. 5 c.c. of water are added to the crucible together with a few drops of concentrated sulphuric acid in order to prevent the subsequent volatilisation of titanic fluoride. About 15 c.c. of hydrofluoric acid are carefully added a few drops at a time. The solution is cautiously evaporated to dryness on a sand bath. The outside of the crucible is freed from sand, the crucible ignited over a burner for 5 minutes and weighed when cool. The result is entered as "weight of crucible + residue." Later the alumina is ignited, together with the silica residue, in the same crucible.

The Ammonia Precipitate.—From 2 grammes to 3 grammes of solid ammonium chloride and an excess of ammonia are added to the hot filtrate (80 deg. to 90 deg.) from the silica, and the solution filtered immediately. The precipitate is washed immediately two or three times with hot water, a hole made in the filter paper, and the precipitate washed back into the beaker from which it has just been filtered. The precipitate is redissolved in a slight excess of hydrochloric acid, and the filter paper is washed until free from chlorides with hot water and kept for ignition later. The combined filtrates are heated to 80 deg. to 90 deg., an excess of ammonia solution is added, the liquid filtered into the beaker previously used, and the precipitate washed free from chlorides by means of a slightly alkaline solution of ammonium nitrate (made by mixing 5 c.c. of concentrated nitric acid with water, adding ammonia until alkaline, and making the solution up to a litre), care being taken that the alumina precipitate does not at any time become dry. The combined filtrates are evaporated to about 100 c.c., and, whilst still hot, 2 c.c. to 3 c.c. of ammonia are added. The liquid is filtered, and the precipitate washed free from chlorides with hot ammonium nitrate solution. The filtrate is reserved for the determination of lime and magnesia.

The three filter papers containing the "alumina" precipitate are dried in the platinum crucible containing the silica residue; the crucible is heated very slowly until the paper is charred, and the temperature raised until all the carbon is burnt off, finally heating for 15 minutes over a Méker burner. After weighing, the ammonia precipitate is very slowly dissolved by fusing with 5 grammes to 6 grammes of fused potassium bi- or pyro-sulphate. The cold cake is transferred to a basin with about 150 c.c. of water, and 10 c.c. of concentrated sulphuric acid are added. The mixture is heated on a water bath until dissolved and made up to 250 c.c. This solution is retained for determination of the iron and titanium.

Notes.—(a) If the clay contains manganese, 2 c.c. or 3 c.c. of bromine water are added to the solution before the ammonia precipitation, and the liquid filtered as usual. In the second precipitation 1 c.c. or 2 c.c. of bromine water are again added, and the same procedure followed as above described.

* When many determinations have to be made, the ignition of precipitates is conveniently done in a muffle at a suitably high temperature.

* Paper read before the Iron and Steel Institute.

† The members were Professor Cobb, Dr. H. G. Colman, Major C. W. Thomas, Messrs. F. H. Brooke, W. J. Brooke, A. Cliffe, J. Allen Howe, Cosmo Johns, W. J. Jones, B. Moore, D. J. Pinkerton, W. J. Rees, and Dr. J. W. Meller, hon. secretary.

(*b*) In the case of a silica brick (containing over 92 per cent. of silica), where the ammonia precipitate is below 5 per cent., only a slight excess of ammonia is added to the washings from the silica, and the excess boiled off. The liquid is filtered and the precipitate washed with ammonium nitrate solution as rapidly as possible. One precipitation only is necessary.

Determination of Ferric Oxide.—A colorimetric process is used for materials which ignite to a white and buff colour; the ordinary permanganate process for those which give deeper colours. The colour of the sample in the crucible after it has been heated for "loss on ignition" is a good criterion to determine which process is the better. A suitable amount of the solution obtained by fusing the ammonia precipitate with pyrosulphate is made up to 250 c.c. 25 c.c. are sufficient for a normal clay containing not more than 1 per cent. of ferric oxide. 5 c.c. of standard iron solution (see below) are made up to 100 c.c. with distilled water. The latter solution is transferred to a burette reading to 0·05 c.c., and another burette is filled with distilled water. Two similar glasses are now required—the test glasses of a colorimeter can be used. Specimen glasses with parallel sides—about 3 cm. square and 8 cm. high—serve excellently. A mixture of 10 c.c. of the solution to be tested with 10 c.c. of potassium thiocyanate solution is made in one test glass, and in the other a mixture of 10 c.c. of a solution of potash alum with 10 c.c. of thiocyanate solution. The tints are viewed by light transmitted through the parallel sides of the glasses. The standard iron solution is added to the test glass with the potash alum solution, and an equivalent amount of distilled water to the other, stirring thoroughly after each addition. When the tints of the liquids in the two test glasses are the same the amount of iron oxide in the sample can be computed.

Example.—Using 1 gramme of clay and the above-mentioned dilutions the percentage of Fe_2O_3 is given by $V\sqrt{v}$, where V represents the number of c.c. of iron solution used; if w grammes of clay be taken and v c.c. of the pyro-fusion solution be diluted to 250 c.c. the percentage of Fe_2O_3 is $25\ V/8v.w$.

For materials containing larger amounts of iron, the pyrosulphate fusion is made up to about 150 c.c., and 20 c.c. of concentrated sulphuric acid employed. If the titanic oxide is to be ignored the solution can be reduced with purified zinc (about 10 grammes) until a drop gives no reddish-brown coloration with potassium thiocyanate. The reduced solution is then diluted to 250 c.c., and titrated with standard potassium permanganate in the usual manner.

If the titanic oxide is to be determined, the solution is to be reduced with sulphur dioxide or ammonium or sodium bisulphite. The solution under treatment should be acidified with sulphuric acid (1 : 1). Add a concentrated solution of ammonium bisulphite, and agitate the mixture thoroughly; or pass a current of sulphur dioxide from a "SO_2 bomb" through the acid solution. Gradually raise the temperature of the solution to boiling, and, when a drop no longer gives a brownish-red coloration with ammonium thiocyanate, the ferric oxide is all reduced. To remove the excess of sulphurous acid place the flask on a sheet of asbestos on a tripod. Add 15 c.c. of dilute sulphuric acid (1 : 1). Cover the flask with the perforated lid of a Rose's crucible. Pass a current of carbon dioxide at the rate of three or four bubbles per second through the solution. The carbon dioxide should be washed by passing it through a column of pumice, soaked in copper sulphate, and a water wash-bottle. The delivery tube passes through the hole in the cover of the flask. Meanwhile the flask is heated to the boiling point of the solution. The velocity of the carbon dioxide is then reduced to about one bubble per second. After 20 minutes to 50 minutes boiling the escaping steam will probably be free from sulphur dioxide, as shown by its failure to discolour a mercurous nitrate test paper. In that case, place the flask in a dish of cold water to cool, while the current of carbon dioxide still bubbles through the solution—one bubble per second.

When cold, the contents of the flask can be titrated with a standard solution of potassium permanganate, as indicated below. The titanium oxide is not reduced by the treatment with ammonium bisulphite.

Standard Iron Solution.—0·6302 gramme of ferric potassium alum is dissolved in water, 5 c.c. of concentrated sulphuric acid added, and the solution made up to 1 litre. 1 c.c. = 0·0001 gramme of Fe_2O_3.

Potassium Thiocyanate Solution.—97 grammes of potassium thiocyanate per litre.

Potash Alum Solution.—0·05 gramme of aluminia (free from iron) are fused with 5 grammes of potassium pyrosulphate, the cold cake extracted with water, 10 c.c. of concentrated sulphuric acid added, and the solution made up to 1 litre.

Determination of Titanium.—For the colorimetric determination of titanium similar test glasses to those employed for the iron determination are used. 50 c.c. of the solution of the cake from the pyrosulphate fusion are mixed with 7 c.c. to 8 c.c. of hydrogen peroxide (free from fluorides), and the solution made up to 100 c.c. 5 c.c. of "standard titanium solution" are mixed with 5 c.c. of hydrogen peroxide, and the solution made up to 100 c.c. One of the test-glasses is about half-filled with the solution to be tested. 10 c.c. of the diluted standard titanium solution is pipetted into the glass and water added from a burette to the latter solution until the tints of the liquids in both glasses are similar. The tints are viewed by light transmitted through the parallel sides of the test glasses.

Example.—If 1 gramme of clay be taken and the dilutions given above employed the percentage of TiO_2 is $25/(10 + v)$ where v is the volume of water added to the 10 c.c. of diluted standard titanium solution.

When w grammes of clay are taken and V c.c. pyro-fusion solution are diluted to 100 c.c. the percentage is

$$\frac{20}{(10 + v)}\ V\ .\ w.$$

The weights of ferric oxide and titanic oxide in the ammonia precipitate have now been determined, and if these are subtracted from the total weight of this precipitate the difference will represent the weight of the alumina in the given sample.

Standard Titanium Solution.—1 gramme of pure titanic oxide is fused with 10 grammes potassium pyrosulphate, the cold cake extracted with cold water, and the 10 c.c. of concentrated sulphuric acid added. After dissolving at as low a temperature as possible the solution is made up to 1 litre; 1 c.c. = 0·001 gramme of TiO_2.

Determination of Lime.—The filtrate from the ammonia precipitate is boiled with 1 gramme to 3 grammes of ammonium oxalate, and 5 c.c. to 10 c.c. of concentrated ammonia solution are added. The solution is agitated and allowed to stand on the water bath for 2 hours. The liquid is filtered, the precipitate washed once (the filtrate is reserved for the determination of magnesia), a hole made in the filter paper, and the precipitate washed into the beaker from which it has been filtered; the precipitate is redissolved in nitric acid and ammonium oxalate and ammonia are added to the boiling solution as before. The liquid is allowed to stand 2 hours to 3 hours, filtered, and the precipitate washed free from chlorides with hot water. The dry precipitate is ignited in a weighed platinum crucible. The ignition is conducted slowly at first, and finally over a blast until the weight is constant—about 15 minutes is ample. The lid should be placed on the crucible for the last 5 minutes. The crucible is weighed rapidly when cool.

Determination of Magnesia.—1 gramme to 2 grammes of sodium ammonium phosphate are added to the first filtrate from the ammonium oxalate precipitate, and the mixture boiled whilst covered with a clock glass. 10 c.c. of concentrated ammonia are added, and the mixture allowed to stand for at least 3 hours. The mixture is stirred vigorously when cold, filtered, and the precipitate washed once with cold water, rejecting the filtrate. A hole is made in the filter paper, the precipitate washed into the beaker from which it has been filtered, and the ammonium magnesium phosphate re-dissolved in nitric acid. The solution is heated to boiling. 1 gramme to 2 grammes of sodium ammonium phosphate and 10 c.c. to 15 c.c. of concentrated ammonia are added, and the mixture allowed to stand for 2 hours. The cold mixture is thoroughly stirred, filtered through a weighed Gooch crucible, and the precipitate washed free from soluble phosphates with cold ammonia solution (1 : 8). The dry precipitate is ignited, cooled and weighed as magnesium pyrophosphate.

Determination of Alkalies.—About 0·5 gramme of finely powdered dry clay is intimately mixed with about 0·5 gramme of ammonium chloride and 3 grammes of calcium carbonate in an agate mortar, and transferred to a platinum crucible, rinsing out the mortar with another gramme of calcium carbonate. The crucible and contents are heated over a small Bunsen flame for about 15 minutes. The lid is kept partly on the crucible whilst the ammonium chloride is being volatilised, then placed in position, and the crucible and contents heated for 1 hour, with the lower third of the crucible at a dull red heat, but not sufficiently high to melt the mass. The crucible is allowed to cool slowly, the cake is transferred to a porcelain dish, and the crucible is thoroughly washed with hot distilled water. After standing 2 minutes or 3 minutes, the cake in the dish is gently crushed to powder with an agate pestle. The mass is digested with 80 c.c. of water for 30 minutes, filtered, and the precipitate washed with hot water eight or nine times; the filtrate should occupy 100 c.c. to 150 c.c. The precipitate is rejected. 10 c.c. of ammonium carbonate (see later) are added to precipitate the lime from the boiling hot filtrate; the liquid is filtered and the filtrate retained. A hole is made in the filter paper and the precipitate washed into the same beaker from which it was filtered, and dissolved in hydrochloric acid (about 5 c.c.). The solution is boiled and a slight excess of ammonia and ammonium carbonate added, and the mixture is filtered into the same beaker as before. The solution is evaporated to dryness in a platinum basin and the dry residue ignited by gradually raising the temperature to faint redness in order to volatilise the ammonium salts. When cold, 3 c.c. of ammonium carbonate are added to the residue in order to precipitate the last traces of lime, the liquid covered with a clock glass, and allowed to stand overnight. The mixture is filtered into a small platinum dish; the precipitate is washed with a solution of ammonium carbonate, and the filtrate is again evaporated to dryness on a water bath. As the liquid tends to spurt during the early stages of the evaporation, the basin is covered with a clock glass, and any liquid adhering to the glass is washed back into the basin. When dry the contents of the dish are moistened with a small amount of concentrated hydrochloric acid and again evaporated. The residue is ignited at a dull red heat, cooled, and weighed; this residue is then washed out into a small porcelain dish and the platinum dish reheated and weighed. The difference in weight represents the alkali chlorides. The solution containing the alkali chlorides is poured into a small porcelain dish, and evaporated almost to dryness with perchloric acid, 10 c.c. of water added, and again evaporated almost to dryness. Six times the weight of the mixed chlorides represents the number of cubic centimetres of 30 per cent. perchloric acid of specific gravity 1·20 to be used in the test. The residue is treated with a mixture of 97 volumes of absolute alcohol, 3 volumes of water, and 0·25 volumes of perchloric acid. The mixture is filtered at once through a weighed Gooch crucible, previously heated to 120 deg., and the residue washed with the alcohol mixture indicated above. The crucible and contents are then dried at 120 deg. for about 45 minutes and weighed. The weight of the precipitate represents potassium perchlorate, this is calculated to potassium chloride, and substracted from the weight of the mixed chlorides to give the weight of sodium chloride. The corresponding amounts of potash and soda are then computed.

Notes.—(*a*) The first precipitate should be well washed, particularly if the amount of alkali is large.

(*b*) The first ignition must not be above 700 deg., and subsequent ignitions should not exceed a faint red heat, or alkalies will be lost by volatilisation.

(*c*) The last washing should be made with ammonium carbonate solution, or the result will be too high.

(*d*) Porcelain or platinum vessels should be used for the evaporations. Glass vessels are objectionable.

Ammonium Carbonate Solution.—100 grammes of ammonium carbonate are dissolved in 100 c.c. of concentrated ammonia (0·880), and the solution made up to 500 c.c. with water.

For "Sulphur" see next analyses. The sulphur determination in firebricks is only useful in special cases, since a large proportion is often obtained by absorption from flue gases. As a result the interior of the brick might show 1 per cent. and the marginal layers between 1 per cent. and 2 per cent.

II. Analysis of Dolomite and Magnesite.

With the analysis of dolomite and magnesite bricks some slight modification of a clay analysis is necessary to prevent contamination of the various precipitates with calcium and magnesium compounds.

Hygroscopic Moisture.—(See clays).

Loss on Ignition.—This is conducted as described for clays and firebricks, but the ignition over a blast burner should be prolonged for another 10 minutes in order to ensure complete decomposition of the carbonates. The hygroscopic properties of calcium and magnesium oxides should be borne in mind when cooling and weighing the ignited sample. It must be observed that porcelain crucibles of inferior quality having soft glazes are easily attacked by these materials.

Alkalies.—(See clays).

Determination of Silica.—1 gramme of the finely-ground material is mixed with about 10 grammes of dry sodium carbonate in a platinum crucible, and gradually heated until the mixture fuses; the contents of the crucible are maintained in a fused condition (with continual agitation) for about half an hour, or, in the case of magnesite bricks, for 45 minutes, as the latter are very difficult to decompose.

For the dissolution, evaporation and filtration of the precipitate see clays.

It is necessary to use an excess of acid in washing the precipitate, owing to the fact that magnesium chloride in solution is hydrolysed on evaporating or boiling, and magnesium oxide or a sparingly soluble basic chloride remains with the silica.

Since not more than 5 per cent. or 6 per cent. of silica is present in an average magnesite or dolomite, two evaporations are unnecessary to remove the whole of the silica.

The precipitate of silica is ignited and weighed, and treated with hydrofluoric acid as described for clays.

Determination of Alumina.—The filtrate from the silica is diluted to about 300 c.c., about 10 grammes of ammonium chloride and 2 c.c. to 3 c.c. of bromine are added, the solution heated to 80 deg. to 90 deg. C., then a slight excess of ammonia is added and the solution heated for 5 minutes.

(The bromine is added to precipitate the manganese.) Prolonged boiling, large excess of ammonia, and a too concentrated solution must be avoided, otherwise the alumina precipitate will be contaminated with much magnesia and lime. The precipitate is filtered and washed free from chlorides as described for clays.

As a general rule, an ordinary dolomite or magnesite rarely contains more than 4 per cent. to 5 per cent. of aluminium and iron oxides, and if the above conditions are maintained two or more precipitations of the alumina are unnecessary. If, however, it is suspected that some magnesia or lime has been precipitated, the precipitate is dissolved in hydrochloric acid, the solution diluted to 250 c.c., 7 grammes or 8 grammes of ammonium chloride and slight excess of ammonia are added, and the precipitate again filtered off and washed free from chlorides. The combined filtrates should now contain all the lime and magnesia.

The alumina precipitate is now ignited in the crucible with the silica residue, weighed and fused with potassium bisulphate as described under clay.

Lime.—To the filtrate from the alumina precipitate (which solution should occupy about 300 c.c.) is added about 2 grammes of ammonium oxalate and the solution heated until the salt is dissolved; great excess of ammonium oxalate, too much heating and strong solutions must be avoided, or magnesia will be precipitated here. Allow to stand for 2 hours, filter and redissolve as described for clays. Reprecipitate the lime with ammonium oxalate (2 grammes), taking the precautions noted above. A second reprecipitation should always be made to ensure that all traces of magnesia have been removed from the lime precipitate.

The precipitate, after washing free from soluble salts, is ignited in a platinum crucible and weighed as usual.

Magnesia.—The combined filtrates from the lime precipitates are concentrated to about 300 c.c., 5 grammes of sodium ammonium phosphate are added, the solution is boiled for a few minutes and 10 c.c. to 15 c.c. of strong ammonia are added, then proceed with the precipitations as for clays.

The bulky precipitate naturally wants a very thorough washing with cold 10 per cent. ammonia solution, and the precipitate should be ignited throughout to a tempera-

ture of not less than 800 deg. C. If too much ammonia or microcosmic salt be added, the precipitate will be contaminated with this salt, which is very difficult to remove by washing.

Iron and Titanium Oxides are determined as for clays.

Phosphorus and Sulphur.—For the determination of these elements a separate 1 gramme of the sample is fused with sodium carbonate as for the silica. A sulphur-free flame is advisable for fusions and evaporations. An asbestos board with the crucible fitted in a hole protects the contents of the crucible when coal gas is used for the fusion. The silica is removed as usual and the filtrate made up to, say, 500 c.c. and 250 c.c., taken for each determination.

The portion for sulphur is neutralised with ammonia, and then just acidified with strong hydrochloric acid, the solution heated to about 90deg. C. and a hot solution of 2 grammes to 3 grammes of barium chloride in 15 c.c. of water is slowly added, with constant stirring.

The solution, after standing 3 hours to 4 hours, is filtered through a small filter paper and the precipitate of barium sulphate washed free from chlorides with hot water.

The precipitate is then ignited to a dull red heat, moistened with a drop of sulphuric acid, again gently ignited, cooled and weighed. The sulphur is calculated as SO_3 by multiplying the weight of $BaSO_4$ by 0·343.

The phosphorus is determined in the other 250 c.c. by first neutralising the solution with ammonia, adding 2 grammes of ammonium nitrate and 10 c.c. of strong nitric acid, heating to about 80 deg. C. and a solution of a gramme or 2 grammes of ammonium molybdate nitric acid, heating to about 80 deg. C., and a solution of a gramme or 2 grammes of ammonium molybdate in 15 c.c. of water is added with constant stirring. The solution is allowed to stand 3 hours or 4 hours and filtered through a small filter paper.

The precipitate is redissolved in ammonia. Add 20 c.c. of ammonium nitrate solution and 1 c.c. of ammonium molybdate to the ammoniacal solution of the ammonium phosphomolybdate first precipitated. Heat the solution at about 80 deg. until gas bubbles begin to form, and add 20 c.c. of hot 5 per cent. nitric acid gradually with constant stirring. After standing 3 hours to 4 hours, filter through a Gooch's crucible, and wash with the mixture previously employed until no brown coloration is produced when a drop of the filtrate is brought in contact with a solution of potassium ferrocyanide. Dry the yellow precipitate and ignite it to about 800 deg. C., and weigh as $24MoO_3.P_2O_5$. This weight, multiplied by 0·0394, gives the weight of P_2O_5 in half a gramme of the sample.

(To be continued.)

SCIENCE IN RELATION TO THE INDUSTRIES OF THE SWANSEA DISTRICT.*

By Cosmo Johns, F.G.S., M.I.Mech.E.

By the Swansea district is meant the region extending from Kidwelly to Port Talbot, west to east, bounded on the north by the outcrop of the Basal Grit (i.e., the lowest beds of the Millstone Grit), and having the port of Swansea as its focus. This district forms a distinct industrial area, with excellent natural resources. The natural resources have determined the character of the industries established in the district, and manual workers with special skill in complex metallurgical operations have been evolved. These workers, when home employment failed them, carried their skill to other parts of the world, and so aided the economic development of the world's metallurgical resources.

The outstanding features of the district under consideration are the abundance and ready accessibility of its coal supplies, and the varied character of the coals, which include long flaming bituminous varieties, extremely pure anthracite, and almost every intermediate kind of coal. Some of them were early recognised as being specially suitable for certain metallurgical operations, and this decided the location and development of the typical industries.

The occurrence of accumulations of blown sand with just sufficient admixture of finely comminuted sea shells to give the necessary bond at a high temperature, when used for furnace hearths, assisted the development of the copper industry. The discovery, about a century ago, that the very pure silica rock found in the Basal Grit could be used to make very refractory bricks which do not shrink on heating, rendered possible high-temperature metallurgical operations, and made the name Dinas famous everywhere. An adequate supply of water, and a natural port capable of furnishing ample accommodation, added to the great advantage of being the most westerly port of industrial Europe, with ready access to the great maritime trade routes, might have been expected to lead to even greater expansion than has actually taken place. If a region so richly endowed by nature has suffered disappointment the logical inference is that an explanation must be sought in the shortcomings of the human element that somehow failed to make the most of the great advantages.

The smelting of copper was early established in the district, and by the decade 1850–60 it enjoyed a practical monopoly of the copper-smelting trade. The copper miners of the world paid tribute to the metallurgical skill of the Swansea copper smelters, and the Welsh process of copper smelting remains to-day, though not now practical, a classical example of a metallurgical art brought to a high degree of efficiency by the genius and persistence of practical men. Unfortunately, no attention was paid to the law of economic science which lays down that only those commercial transactions that are beneficial to both seller and buyer are of real and permanent value to the industry concerned. The mine owners of Chile and other countries, who exported their ores to Swansea, considered—probably with good reason—that those who controlled the smelting monopoly dealt unfairly with them. Copper-smelting plants were erected abroad, and the copper industry of Swansea received a blow from which it never recovered. Swansea, indeed, could not have maintained permanently its premier position as a copper-smelting district, for vast ore supplies have been discovered which could not have been profitably imported, but sufficient supplies were always available had the industry expanded normally. The natural resources and facilities of the district are unimpaired, but a new factor has been introduced which complicates the problem. The metallurgy of copper has made stupendous advances, and lean ores of vast extent are cheaply mined in certain districts. Metallurgical processes dealing with charges much greater than even those of the iron and steel industry have been worked out, and water-jacketed blast furnaces working a total charge of 3,000 tons per 24 hours have been operated in America for years. Converters handling 80 tons of matte and blowing for 8 hours are in successful operation. Electrolytic plants producing large quantities of anode copper are at work, and refining furnaces dealing with charges of 220 tons of copper are used with very low fuel consumption. In the utilisation of these lean ores the trained metallurgical engineer has had his great opportunity in the application of scientific principles to industrial problems. His striking triumph deserves the careful consideration of those engaged in other metallurgical industries.

The spelter industry, in which metallic zinc is produced, is a second local industry, the changing fortunes of which merit careful consideration. Eminently suited to the district, and conveniently situated for the importation of ores, it reached substantial proportions. Long before the war it had ceased to expand, a sure sign of decay in an industry for the product of which the world's demand was increasing by leaps and bounds. The metallurgy of zinc is apparently simple, but in reality it is more complex than that of any other industrial metal used on a large scale. While the easily-smelted calamine ores were available, the Swansea spelter industry could hold its own, and ignore the changes through which the industry was passing elsewhere. But when flotation methods had been perfected, and the concentrates of the complex ores of Broken Hill (Australia) were available for smelting, the metallurgical practice of the Swansea district failed to make use of its opportunity. The industry stagnated locally while great developments went on in other places, and on the outbreak of war, out of a total consumption of over 200,000 tons of spelter per annum in this country, nearly three-quarters had to be imported. The complex ores of our own Colonies had to find their market in Belgium and Germany, where the metallurgical skill and commercial ability to utilise them could be found. In the Swansea district such sulphide ores as were used were roasted so as to deliver into the atmosphere the sulphurous gases, which destroyed vegetation in the immediate neighbourhood. In Belgium sulphuric acid was made from these gases, and the spelter industry could earn handsome profits. This pre-war stagnation of the British spelter trade stands on record as a typical case of the consequences of an industry neglecting to observe changing conditions and ignoring the scientific principles on the application of which the success of the industry depends.

To-day the conditions are different. Under outside pressure smelting extensions have been erected, acid-recovery plants are in course of erection, and the industry is in process of rejuvenation. But with all the extensions, built and projected, the total smelting capacity will only amount to about half the national consumption before the war. This is far from meeting the demand of the Empire for smelting facilities for the ores it does and can produce. The American zinc smelting centres are so situated that they cannot deal with them, and are sufficiently occupied in exploiting their own ore reserves. Australia, owing to climatic and other conditions, cannot smelt her great output of complex ores. Only Great Britain, Belgium, and Germany remain to be considered. The moral is obvious. Research has been in progress during recent years. Electric furnaces for zinc distillation have reached such a stage that a commercial process might be announced at any time. The electrolytic method of obtaining pure zinc has long passed the experimental stage, and large plants are in operation. One in America now approaching completion will have an output nearly equal to the whole British output before the war. The future of the spelter industry will rest with those who can efficiently apply the principles of science to its changing conditions. Only large plants will be able to afford the necessary skilled supervision, to carry out and profitably apply the research work required, and to deal with the commercial problems involved. A recognition that the old era has come to an end and a new one commenced is the first requirement for a successful future for the spelter industry of the district. A grouping of the smaller units would perhaps be the best guarantee of their future stability.

These two examples of typical industries which, despite the favourable circumstances of their location, have suffered such vicissitudes, have been cited because they serve to illustrate the danger which attends any industry which fails to look ahead and to prepare itself to solve those problems which the progress of science and changing economic conditions are always presenting. The infraction or neglect of the laws of science, economic as well as physical, carries with it a dire penalty which none may escape.

* Abstract of a lecture delivered at Swansea, on October 18, during the meeting of the Refractory Materials Section of the Ceramic Society.

CATALOGUES.

Drawing Pencils.—The American Lead Pencil Company, 173, Lower Clapton-road, E. 5, send a pamphlet catalogue dealing with pencils for the drawing office and containing some useful memoranda and clever mechanical drawings in perspective. They offer to send a booklet free on request.

Steam Condensers.—A somewhat comprehensive series of machines for condensing operations is described in a catalogue received from the Wheeler Condenser and Engineering Company, New Jersey, U.S.A. Surface condensers in several forms, jet and barometric condensers, air, water and dry vacuum pumps, natural and forced-draught water cooling towers, and other items of such plant are well illustrated and described. Most of the plant is on the large scale. Some useful technical data is also given making an exceedingly compact and instructive catalogue.

The Future of the Dutch Indies: Their Coal Resources.—A Bremen correspondent of the *Weser Zeitung* (August 5) professes to believe that Holland is in great danger of having her colonies robbed from her by England or Japan, and claims that opinion in Holland has been converted to the belief that the only way for the country to save her colonial possessions in the Dutch Indies is to make them totally independent of the economic support of Holland, their Mother Country. With this object it will be necessary to industrialise the colonies, which presents no very great difficulty, since large coal fields are in existence which will enable the colonies to dispense with English bunker coal, while, if the South Sea coaling stations were able to rely on coal from the Dutch Indies, the supremacy of England and Japan in an economic direction would be to a certain extent neutralised. There are, it is true, only two large coalfields, viz., the Ombilin mines in Sumatra, and the mine in Poeloe-Lavet, a small island near the South-East Coast of Borneo. The total output of coal is not sufficient at present to meet the requirements of the Dutch Indies, but the deposits are so rich that its extraction would pay well, especially as in quality it is equal to foreign coal. The Ombilin mines are estimated to contain 200,000,000 tons, of which between 1892 and 1914 only 5·8 million tons in all were extracted. This was due to the sparse population of Sumatra and Borneo, and to the difficulty of obtaining labour, especially as the Javanese are indolent, averse to leaving their homes and in other respects are reckoned indifferent workers. Opposition to the idea of industrialising the Dutch Indies is expressed in many quarters; but as it is becoming more and more necessary in the interests of national defence, Holland will certainly devote herself after the war to removing the difficulties by employing much capital and all possible vigour.

Synthetic Phenol.—Benzene, C_6H_6, is a chemically indifferent liquid hydrocarbon. When one hydrogen atom is replaced by OH, phenol is formed $C_6H_5.OH$; though also known under the name carbolic acid, phenol is a neutral crystallised, hygroscopic substance; metals taking the place of the H in OH form salts with it, however, thus justifying the name acid. When three more hydrogen atoms of benzene are replaced by three groups of NO_2, trinitro phenol or picric acid is formed, which is decidedly acid in character, and used with primers is a high explosive, though the crystals can be melted at 122.5 deg. C. and even be sublimed without decomposing. Phenol is utilised for pharmaceutical purposes, in the dye-stuff industry, for the manufacture of certain resin-like insulators (bakelite, &c.) and for the manufacture of picric acid. Before the war the United States required about 5,000,000 lb. of phenol per year; by 1917 that figure had risen to 72,000,000 lb. Some phenol is found in coal tar, but most of it has to be manufactured from benzene. The conversion of benzene into phenol looks simple, and is not really difficult in factories; but the ordinary process is very wasteful. By means of fuming sulphuric acid the benzene is first transformed into the sulphonic acid $C_6H_5.SO_3H$, which is turned into a sodium salt; this salt is fused with caustic soda to yield phenol and sodium sulphite; the sulphite is utilised again in forming the salt in question. But a great excess of sulphuric acid has to be used, which afterwards has to be neutralised with lime; to remove the calcium sulphate the solution is heated to 115 deg. C. and filtered; this sulphate has next to no value, and some sulphate always remains in solution and has to be precipitated by carbon dioxide, as it would remain a disturbing factor in the subsequent operations. In order to reduce this waste of raw materials and of sulphuric acid in the first instance, Daniel Tyrer has recently passed benzene vapours through the acid at temperatures up to 185 deg. C. Another process, worked out by L. M. Dennis, of the Cornell University, and Hans Bull, of the Barrett Company, New York, is described by A. G. Peterkin in *The Journal of Industrial and Engineering Chemistry* of last September. The main novelty lies in the sulphonation. Although the benzol sulphonic acid is only slightly soluble (to 3 per cent.) in benzene, the sulphonation and the extraction of this acid from the mixture of the sulphuric acid and the sulphonic acid can be carried out simultaneously by passing the benzene through perforated pipes into the acid, the liquids circulating through five extractors in such a way that the two acids are separated. Dennis and Bull further do not add the dried sulphonic acid to the fused caustic soda, but resort to "liquid fusion" by passing the hot solution into the boiling caustic. In this manner labour and materials are said to be saved.